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Public Health Service
Washington, D. C.

December 1962

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

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ADVANCE REPORT

Reports received by the Public Health Service Radiation Surveillance Center for August and September 1962 have indicated fresh fallout from both U. S. and U.S.S.R. testing. The Service's Pasteurized Milk Network reports show daily levels of radioactive iodine-131 from July Nevada tests declined in Salt Lake City milk from 730 to 100 μμc per liter in August. The August Salt Lake City monthly average was 330 μμc/1. The only other station with an iodine-131 August monthly average over 40 μμc/1 was Laramie, Wyoming with 160 μμc/1. The September monthly iodine-131 averages for both Salt Lake City, Utah and Laramie, Wyoming were 40 μμc/1.

Apparent effects of the U.S.S.R. nuclear tests appeared in September when the Pasteurized Milk Network monthly tabulation of 62 stations showed an average daily iodine-131 concentration of 60 μμc/1 compared to the August average of 20 μμc/1. During September the monthly averages of 40 stations were above 20 μμc/1 compared to 6 stations in August. Of these 40, the following 9 stations, all in the northern States, had September monthly averages of 100 μμc/1 or more:

	μμc/l		μμc/l
Palmer, Alaska	730	Buffalo, New York	100
Chicago, Illinois	100	Minot, North Dakota	170
Des Moines, Iowa	120	Rapid City, South Dakota	130
Detroit, Michigan	120	Milwaukee, Wisconsin	120

3<

SECTION I.—AIR AND PRECIPITATION

Fission Product Beta Activity in Airborne Particulates and Precipitation

Measurements of gross beta activity of airborne particulates and precipitation are among the earliest and most sensitive indicators of increases of fission product activity in the environment. However, a direct evaluation of biological effects is not possible from these data alone.

Of the several networks or sampling programs making such measurements, the Radiation Surveillance Network, the Naval Research Laboratory, the National Air Sampling Network, and the Canadian Radioactive Fallout Study Program are represented in the following reports.

RADIATION SURVEILLANCE NETWORK
July 1962

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network (RSN) was established in 1956 in cooperation with the Atomic Energy Commission primarily to provide a means of promptly determining increasing levels of radioactivity in air and precipitation due to fallout from nuclear weapons tests. Prior to September 1961, the Network consisted of 45 stations. Following the September 1961 resumption of nuclear weapons testing by the U.S.S.R., the Network has been expanded over a period of several months to 72 stations, whose locations are shown in figure 1.

Air

Daily 24-hour air samples are collected by a high volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field measurements with a portable survey meter enable the station operator to estimate the amount of beta activity in airborne particulates at the station five hours after collection by comparison with a known Sr^{90}–Y^{90} source. This 5-hour delay eliminates interference from naturally-occurring radon daughters. Each operator then reports his field estimate by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C., to provide a daily national report.

The filters are then forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and recounted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day interval, make possible the estimation of the age of fission products and extrapolation of the

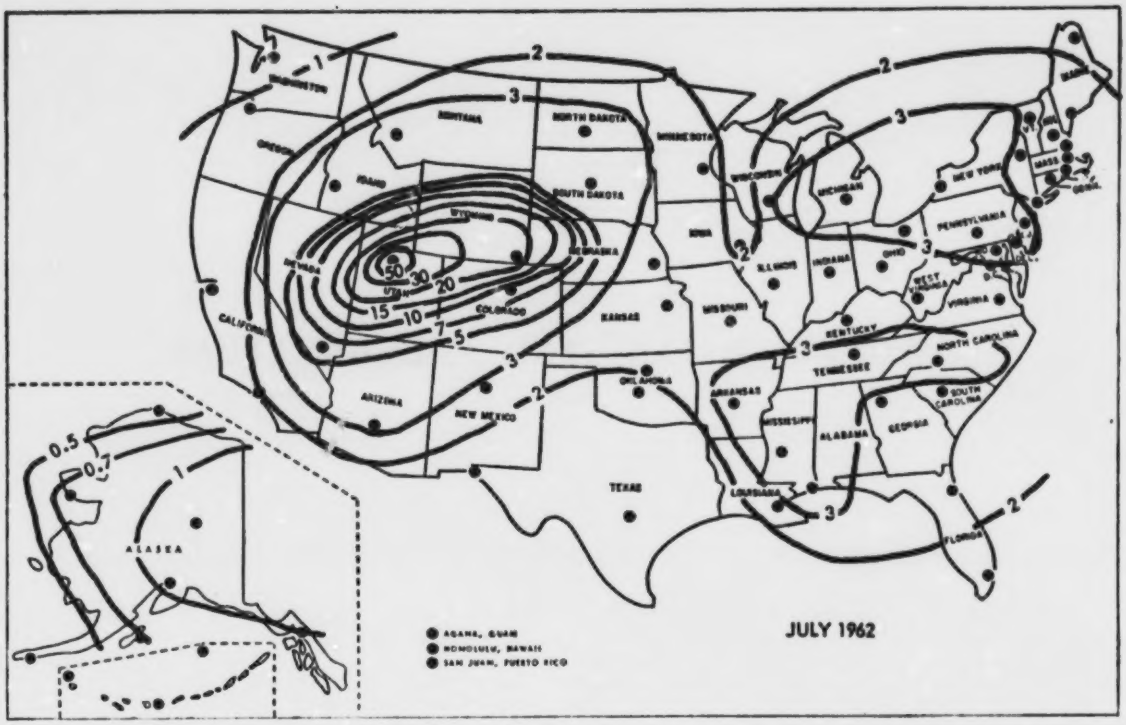
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MISSISSIPPI
MICHIGAN
INDIANA
KENTUCKY
TENNESSEE
ALABAMA
OHIO
WEST VIRGINIA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
PENNSYLVANIA
NEW YORK
MAINE
MASS.
CONN.
ALASKA
1
2
3
5
7
10
15
20
30
50
0.5
0.7
AGANA, GUAM
HONOLULU, HAWAII
SAN JUAN, PUERTO RICO
JULY 1962

Figure 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$) JULY 1962

activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant).*

Although gross beta concentration is usually presented without reference to age, it is apparent that fission product activity is more adequately described when the age parameter is also given. An example of the interpretative usefulness of age of fission product data is presented in "Mid-May Iodine–131 in Fallout in the Midwest" in *RHD,* September 1962, Section V. Because of the difficulty in determining a meaningful monthly average of age of fission products, such data have not yet been presented with the RSN data in *RHD*.

The average fission-product beta concentrations in surface air during July 1962 as determined by laboratory analysis are tabulated in table 1 and presented by means of concentration contours in figure 1. Experience has shown that field estimates are generally comparable to laboratory analyses, except at low levels, where the former are usually higher because of natural thoron daughters.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels having collection areas of 0.4 m². A 500 ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml (equivalent to 0.5 mm rainfall), the volume of precipitation is reported, but no analysis is made.

The June 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and millimicrocuries per square meter ($m\mu c/m^2$) are presented in table 2. Placement of a "less than" sign (<) with an average concentration or total deposition value indicates that the sum of the "less than" daily deposition values is 10 percent or more of the

---

* In this expression, A is the activity at time T after fission product formation. Units are arbitrary.

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, JULY 1962

[Concentrations in $\mu\mu c/m^3$]

Station location		Number samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average*
City	State				
Adak	Alaska	24	1.6	<0.10	0.40
Anchorage	Alaska	31	5.3	<0.10	1.1
Attu	Alaska	30	3.2	<0.10	0.50
Fairbanks	Alaska	16	2.7	<0.10	1.6
Juneau	Alaska	19	3.4	0.47	1.0
Kodiak	Alaska	31	2.9	<0.10	0.71
Nome	Alaska	28	4.7	<0.10	0.93
Point Barrow	Alaska	28	1.8	<0.10	0.43
St. Paul Island	Alaska	16	1.1	<0.10	0.31
Phoenix	Ariz	30	14	1.2	2.1
Little Rock	Ark	31	12	1.1	3.3
Berkeley	Calif	31	2.5	0.17	1.2
Los Angeles	Calif	23	3.1	0.84	2.0
Denver	Colo	31	93	1.3	7.3
Hartford	Conn	31	2.5	0.61	2.5
Dover	Del	22	7.1	1.5	4.1
Washington	D. C	31	6.9	0.81	2.9
Jacksonville	Fla	31	5.5	0.72	2.4
Miami	Fla	31	3.4	0.90	1.6
Atlanta	Ga	31	4.8	0.47	2.5
Agana	Guam	13	19	<0.10	2.9
Honolulu	Hawaii	29	2.5	0.18	1.1
Boise	Idaho	28	25	2.1	4.2
Springfield	Ill	31	6.5	1.1	2.5
Indianapolis	Ind	30	4.5	0.83	2.4
Iowa City	Iowa	31	3.9	0.69	1.9
Topeka	Kans	31	5.9	0.94	2.3
Frankfort	Ky	29	4.9	0.93	2.1
New Orleans	La	31	5.7	0.82	2.5
Augusta	Maine	31	5.1	0.12	2.3
Presque Isle	Maine	25	3.7	0.15	1.4
Baltimore	Md	31	6.6	1.2	3.2
Rockville	Md	22	6.5	0.90	3.3
Lawrence	Mass	31	4.4	0.16	2.0
Winchester	Mass	28	4.5	0.17	2.3
Lansing	Mich	31	6.0	1.7	3.5
Minneapolis	Minn	31	5.6	0.80	2.3
Jackson	Miss	27	12	0.43	3.7
Pascagoula	Miss	21	8.9	1.0	3.8
Jefferson City	Mo	31	8.1	1.1	2.8
Helena	Mont	31	7.4	0.79	3.7
Lincoln	Nebr	21	5.5	0.96	2.7
Las Vegas	Nev	30	17	0.59	6.6
Concord	N. H	21	5.9	0.29	2.9
Trenton	N. J	31	4.6	1.1	2.7
Santa Fe	N. Mex	31	8.7	1.2	2.9
Albany	N. Y	30	5.1	0.34	2.8
Buffalo	N. Y	30	6.1	1.8	3.3
New York	N. Y	17	4.6	0.92	2.4
Gastonia	N. C	31	7.9	0.84	3.5
Bismark	N. Dak	31	8.6	0.71	3.2
Columbus	Ohio	30	6.5	0.99	2.8
Painesville	Ohio	30	5.5	1.2	3.0
Oklahoma City	Okla	31	5.1	0.76	1.9
Ponca City	Okla	29	3.2	0.12	1.1
Portland	Ore	31	3.0	0.64	1.6
Harrisburg	Pa	24	6.3	0.28	3.4
San Juan	P. R	15	2.5	0.84	1.5
Providence	R. I	31	5.9	0.18	2.5
Columbia	S. C	27	4.9	0.40	2.6
Pierre	S. Dak	30	40	0.85	4.0
Nashville	Tenn	30	9.1	1.1	3.4
Austin	Tex	29	4.2	0.68	1.6
El Paso	Tex	30	3.9	0.66	1.4
Salt Lake City	Utah	31	595	1.7	51
Barre	Vt	31	5.8	0.33	3.0
Richmond	Va	31	4.0	0.78	2.4
Seattle	Wash	30	2.2	0.47	0.95
Charleston	W. Va	29	4.6	1.2	2.6
Madison	Wis	31	5.1	1.2	3.0
Cheyenne	Wyo	29	378	1.3	21
Network average					3.4

* Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, JULY 1962

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
City	State		
Adak	Alaska	*	*
Anchorage	Alaska	610	6
Attu	Alaska	*	*
Fairbanks	Alaska	*	*
Juneau	Alaska	650	55
Kodiak	Alaska	*	*
Nome	Alaska	*	*
Point Barrow	Alaska	*	*
St. Paul Island	Alaska	*	*
Phoenix	Ariz	*	*
Little Rock	Ark	410	39
Berkeley	Calif	*	*
Los Angeles	Calif	*	*
Denver	Colo	*	*
Hartford	Conn	2,000	75
Dover	Del	*	*
Washington	D. C	2,500	85
Jacksonville	Fla	510	69
Miami	Fla	1,700	180
Atlanta	Ga	†<360	†<24
Agana	Guam	*	*
Honolulu	Hawaii	*	*
Boise	Idaho	*	*
Springfield	Ill	2,200	120
Indianapolis	Ind	790	160
Iowa City	Iowa	500	130
Topeka	Kans	1,200	83
Frankfort	Ky	700	48
New Orleans	La	990	90
Augusta	Maine	640	43
Presque Isle	Maine	500	91
Baltimore	Md	930	55
Rockville	Md	*	*
Lawrence	Mass	680	69
Winchester	Mass	710	31
Lansing	Mich	620	25
Minneapolis	Minn	2,100	280
Jackson	Miss	†<350	†<6.5
Pascagoula	Miss	550	110
Jefferson City	Mo	2,600	53
Helena	Mont	7,400	300
Lincoln	Nebr	2,200	240
Las Vegas	Nev	*	*
Concord	N. H	*	*
Trenton	N. J	1,400	8.3
Santa Fe	N. Mex	990	52
Albany	N. Y	660	15
Buffalo	N. Y	820	16
New York	N. Y	*	*
Gastonia	N. C	1,000	82
Bismarck	N. Dak	1,500	110
Columbus	Ohio	850	89
Painesville	Ohio	960	100
Oklahoma City	Okla	470	9
Ponca City	Okla	600	64
Portland	Ore	*	*
Harrisburg	Pa	1,400	18
San Juan	P. R	350	17
Providence	R. I	650	23
Columbia	S. C	610	81
Pierre	S. Dak	2,100	94
Nashville	Tenn	810	29
Austin	Tex	*	*
El Paso	Tex	980	57
Salt Lake City	Utah	6,700	140
Barre	Vt	1,000	130
Richmond	Va	460	59
Seattle	Wash	630	5
Charleston	W. Va	890	110
Madison	Wis	1,200	62
Cheyenne	Wyo	2,600	170

* No evaporated sample received.

† Placement of a "less than" sign (<) with an average concentration or total deposition value indicates that the sum of the "less than" *daily* values is 10 percent or more of the total, so that the true total or average is considered significantly less than the value shown.

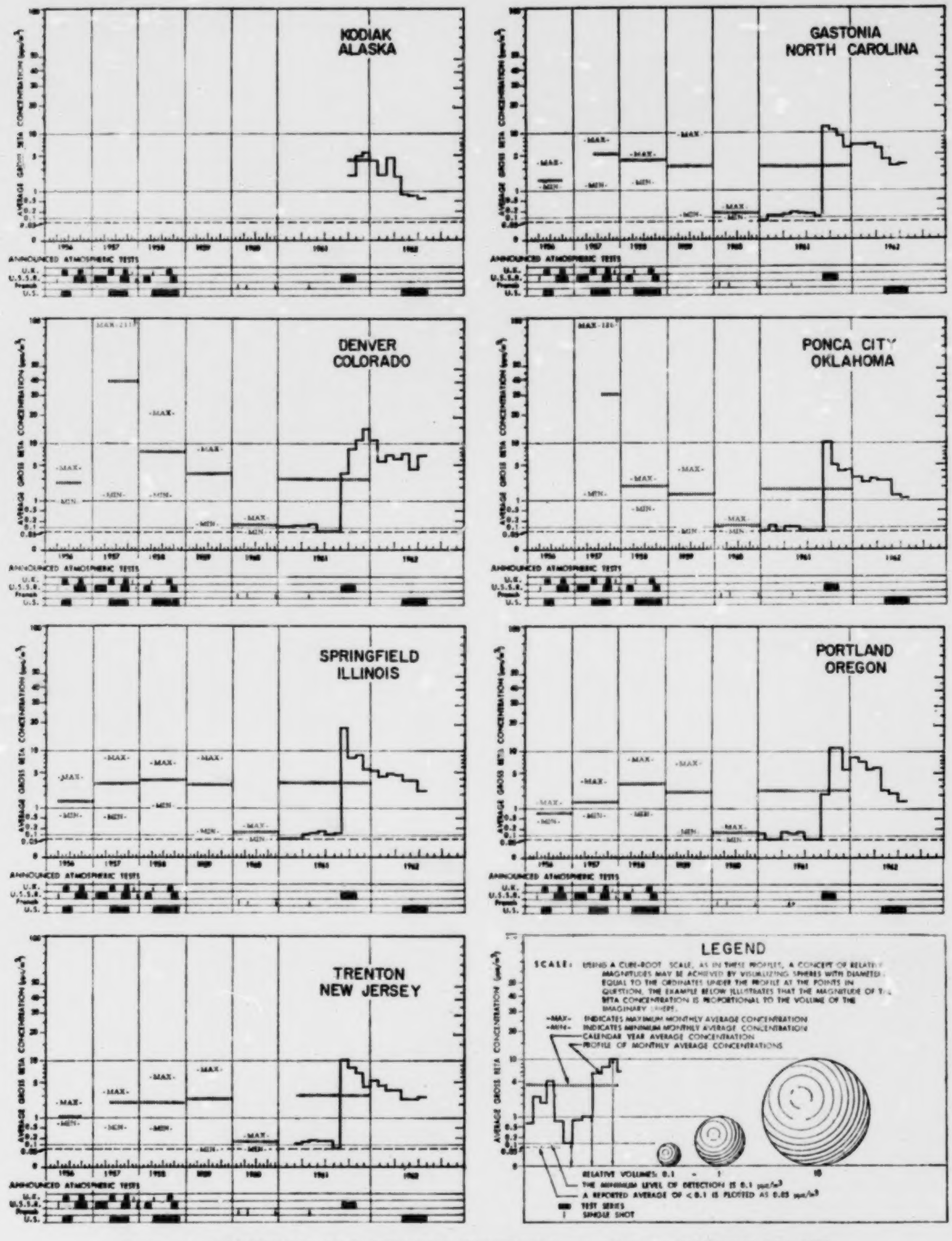

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–JULY 1962

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total deposition so that the true total or average is considered significantly less than the value shown.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through July 1962, are shown in figure 2.

THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM

June 1962

U.S. Naval Research Laboratory

Radioactivity measurements of surface air samples collected at various sites near the 80th Meridian (West) have been made since 1956. Sampling locations are shown in figure 3. This program is operated by the U.S. Naval Research Laboratory (NRL) with the cooperation of interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile, which collect the samples and forward them to NRL for analysis. Partial financial support of this program is provided by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

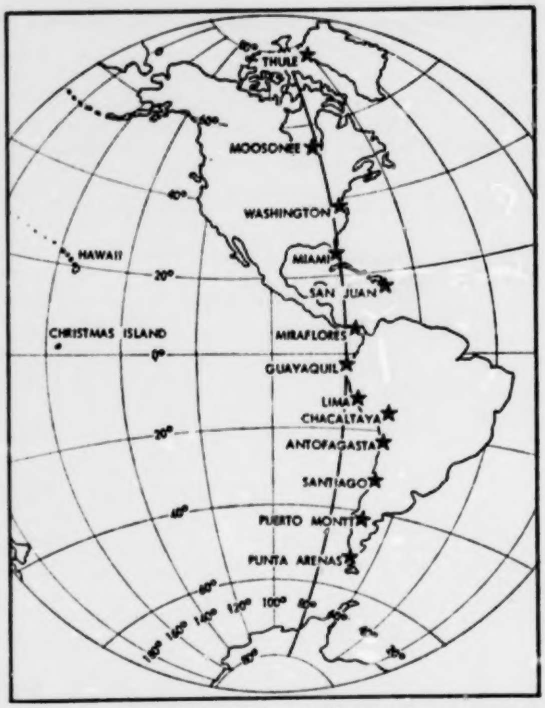
THULE
MOOSONEE
WASHINGTON
HAWAII
MIAMI
SAN JUAN
CHRISTMAS ISLAND
MIRAFLORES
GUAYAQUIL
LIMA
CHACALTAYA
ANTOFAGASTA
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
80°
60°
40°
20°
0°
20°
40°
60°
80°
180°
160°
140°
120°
100°
80°
60°

FIGURE 3.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

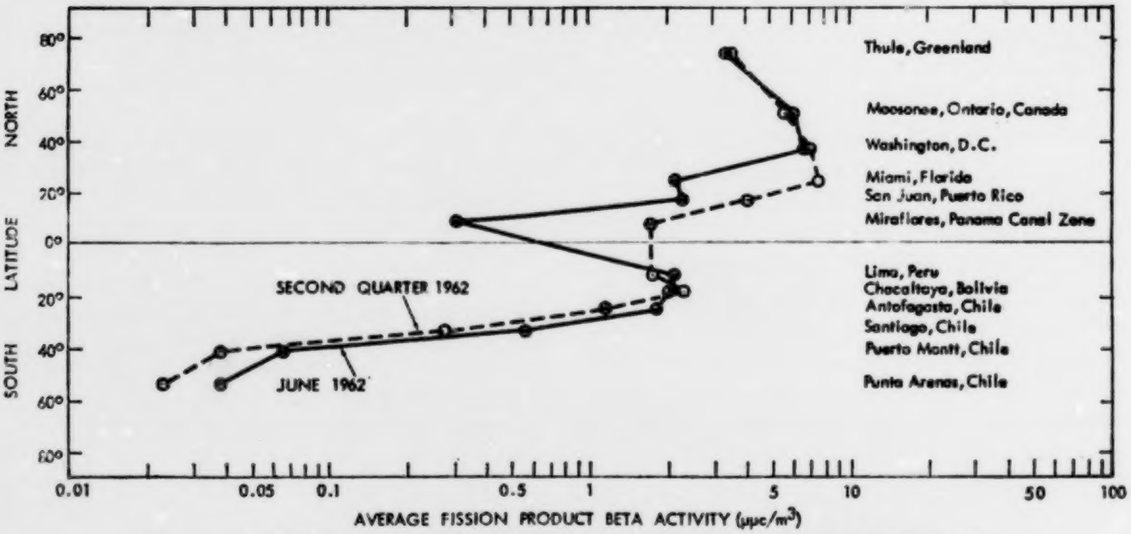

FIGURE 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENT OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), JUNE 1962

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TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL,[a] JUNE 1962

[Average concentrations in $\mu\mu c/m^3$]

Date	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, P. R.	Mauna Loa, Hawaii[c]	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1														
2	0.018	0.021	0.159	1.68	4.22	2.90	[b]—	1.00	0.805	3.48	2.65	4.76	3.62	
3														5.31
4														
5														
6														
7														
8	0.018	0.056	0.377	1.84	2.36	1.52	—	0.210	3.16	3.99	2.34	7.91	7.50	
9														4.95
10														
11														
12														
13														
14														
15	0.041	0.063	0.964	2.63	1.39	2.85	—	0.209	2.42	3.39	1.37	5.40	8.00	
16														2.82
17														
18														
19														
20														
21														
22	0.052	0.050	—	1.02	1.46	2.04	—	0.193	2.54	3.16	1.81	7.78	4.95	
23														1.79
24														
25														
26														
27														
28	0.057	0.078	—	—	1.33	1.76	—	0.193	2.21	4.30	3.06	8.81	5.21	
29														1.58
30														
Weighted average	0.038	0.055	0.558	1.80	2.00	2.18	—	0.309	2.37	3.64	2.15	6.93	6.11	3.32

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period of the portion of the sampling period occurring in June 1962.

[b] Dash indicates samples were not received.

[c] Mauna Loa data has been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters) and about equally distant north and south of the equator.

The sampling procedure involves drawing air continuously for a 7-day period at a rate of approximately 1200 cubic meters per day through an 8-inch diameter, high efficiency filter, using a positive displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. Data are not extrapolated to time of collection.

The data in table 3 and the June profile in figure 4 show a conspicous low concentration at Miraflores compared to the adjacent stations. This was perhaps the result of two factors: (a) fresh radioactivity from U.S. Pacific tests went much further south while the Northern Hemisphere stations remained high because of the background of 1961 U.S.S.R. debris (plus perhaps some fallout from U.S. Pacific tests); and (b) the rainy season at Panama depressed the activity concentrations in the ground-level air.

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NATIONAL AIR SAMPLING NETWORK
Second Quarter 1962

Division of Air Pollution, Public Health Service

The Public Health Service developed its National Air Sampling Network in 1953 to secure basic data on the nature and extent of air pollution throughout the United States and to detect trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

The current basic network consists of 110 sampling stations operating every year in 73 large cities and 37 nonurban areas. In addition to these every-year stations, 130 cities have stations which operate every other year. Thus, there are 240 sampling stations in all, of which about 175 are active in any given year.

The network stations are manned by cooperating Federal, State, and local agencies. Twenty-four hour samples of suspended particulate matter representing approximately 2000 cubic meters of air are collected on glass fiber filters on a bi-weekly random sampling schedule. The analyses of these samples include the measurement of total quantity of suspended particulate matter, the organic matter soluble in benzene, and gross beta radioactivity. Selected samples are analyzed also for nitrates, sulfates, and a number of metals.

Gross Beta Activity in Air

Gross beta activity data by states, for the years 1953 through 1958, were submitted by the Division of Radiological Health, Public Health Service, in testimony before the Joint Committee on Atomic Energy Hearing on Fallout from Nuclear Weapons Tests, Volume I, May 1959, pages 173-185. Subsequent data have been published quarterly in *Radiological Health Data* beginning with the October 1960 issue. Second quarter 1962 data are presented in table 4.

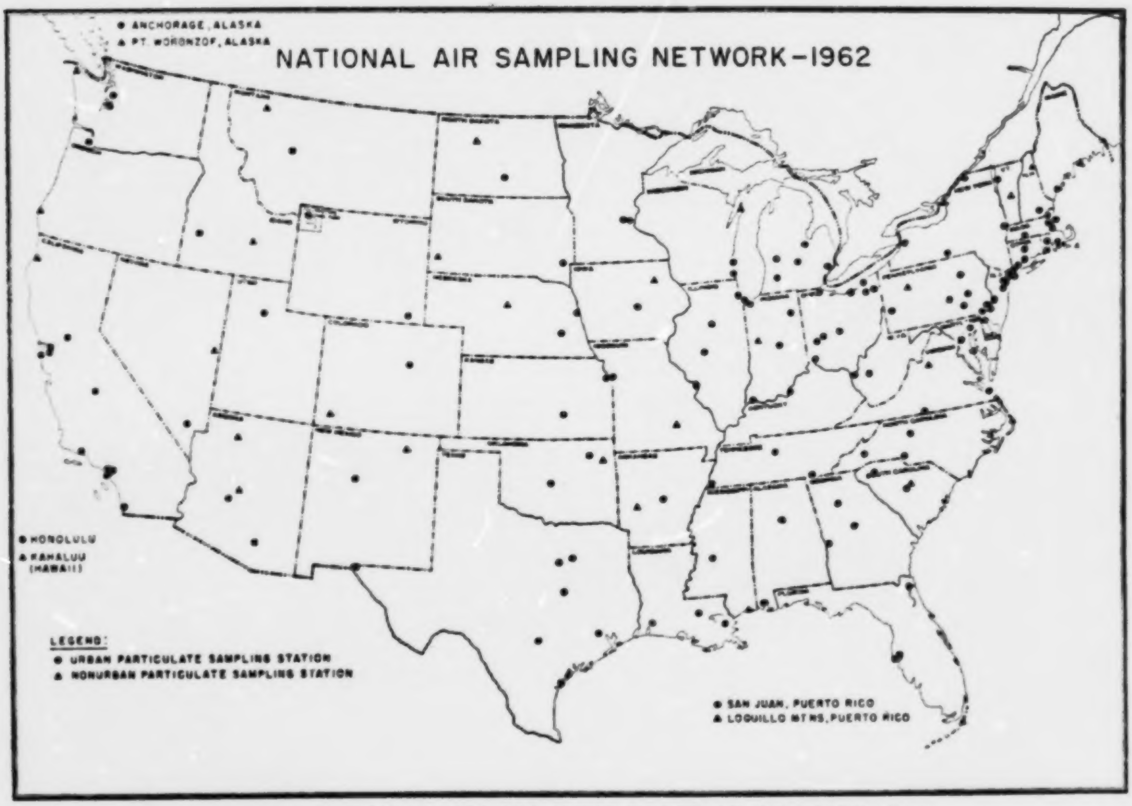
● ANCHORAGE, ALASKA
▲ PT. WORONZOF, ALASKA
NATIONAL AIR SAMPLING NETWORK-1962
● HONOLULU
▲ KAHALUU (HAWAII)
LEGEND:
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
● SAN JUAN, PUERTO RICO
▲ LOQUILLO MTNS, PUERTO RICO

FIGURE 5.—NATIONAL AIR SAMPLING NETWORK STATIONS, 1962

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, SECOND QUARTER 1962

[Concentrations in pc/m³]

Station location		No. of samples	Minimum	Maximum	Average
Alabama:	Birmingham	6	4.1	15.7	9.7
	Mobile	6	2.2	14.6	7.9
Alaska:	Anchorage	7	1.4	6.6	3.7
	Pt. Woronzof *	7	0.5	4.9	2.6
Arizona:	Grand Canyon Pk *	6	6.1	17.0	11.9
	Maricopa Co *	6	6.3	33.8	15.2
	Phoenix	6	7.7	16.3	11.8
	Tucson	6	6.0	18.2	11.0
Arkansas:	Little Rock	6	2.5	12.9	8.7
	Montgomery Co *	5	3.2	12.5	7.5
California:	Burbank	7	2.5	20.2	8.5
	Fresno	6	3.4	15.1	7.9
	Humboldt Co *	6	0.8	3.5	1.9
	Los Angeles	7	1.7	20.1	6.5
	Oakland	5	0.7	14.5	5.4
	Pasadena	5	2.1	10.0	4.7
	Richmond	7	0.7	10.5	3.4
	Sacramento	6	2.3	18.6	7.0
	San Diego	7	2.3	12.3	6.5
	San Francisco	6	0.6	16.9	3.9
	Santa Barbara	6	1.4	16.7	4.8
Colorado:	Denver	6	4.4	7.3	5.5
	Montezuma Co*	5	5.0	15.0	8.6
Connecticut:	Bridgeport	6	3.6	8.9	6.3
	Hartford	6	2.9	7.0	5.5
	New Haven	6	2.2	11.8	7.3
	Stamford	6	2.1	11.7	5.6
Delaware:	Kent Co*	4	4.6	28.4	11.1
	Wilmington	7	1.9	8.0	5.0
District of Columbia:	Washington	6	3.3	8.2	6.3
Florida:	Florida Keys*	5	1.5	8.6	5.2
	Jacksonville	6	1.2	16.0	7.1
	St. Petersburg	7	1.9	13.0	7.1
	Tampa	6	1.0	12.8	7.5
Georgia:	Atlanta	6	3.1	11.1	6.1
	Columbus	6	2.8	18.0	7.3
	Macon	6	2.8	9.6	6.8
Hawaii:	Honolulu	6	2.0	4.6	3.1
	Kahaluu *	6	1.3	5.9	3.8
Idaho:	Boise Idaho	6	5.2	19.0	9.3
	Butte Co *	7	5.5	11.0	8.6
Illinois:	Chicago	7	3.2	10.3	6.5
	Cicero	6	2.1	7.0	5.2
	Peoria	6	5.4	10.7	7.9
	Springfield	6	3.5	16.3	8.9
Indiana:	East Chicago	5	1.6	11.2	4.9
	Evansville	6	3.3	6.2	4.8
	Fort Wayne	7	4.8	15.8	8.5
	Gary	6	4.9	12.8	7.4
	Indianapolis	6	4.0	11.6	7.4
	Montgomery Co *	6	3.6	11.4	7.5
Iowa:	Clayton Co *	6	2.6	16.1	7.5
	Des Moines	7	3.2	13.1	6.5
Kansas:	Kansas City	6	1.9	10.5	5.9
	Wichita	6	5.1	16.2	10.1
Kentucky:	Louisville	5	3.1	9.0	5.6
Louisiana:	Baton Rouge	7	2.2	14.4	9.6
	Lake Charles	6	0.6	10.3	6.3
	New Orleans	6	2.9	9.4	6.7
Maine:	Acadia Nat Pk *	4	3.2	8.9	5.4
	Portland	6	2.9	7.1	4.9
Maryland:	Baltimore	6	5.6	16.7	8.5
	Calvert Co *	6	5.3	11.6	8.0
Massachusetts:	Boston	7	1.3	11.5	6.4
	Fall River	7	3.2	15.5	9.7
	Lawrence	6	2.6	11.7	7.7
	Lynn	6	3.7	10.4	6.1
	Quincy	5	5.5	10.3	8.5
	Somerville	6	4.0	12.3	7.4
	Springfield	6	1.0	7.4	5.2
Michigan:	Detroit	7	4.3	7.1	5.4
	Grand Rapids	4	4.4	6.2	5.1
	Kalamazoo	6	4.1	17.2	7.8
	Lansing	6	2.7	7.2	5.1
	Saginaw	6	3.8	11.4	8.0
Minnesota:	Minneapolis	6	2.2	7.2	4.7
	St. Paul	5	3.4	6.7	5.3
Mississippi:	Jackson	5	2.9	9.5	6.9
	Jackson Co *	5	1.5	10.0	6.5
Missouri:	Kansas City	5	5.0	9.8	6.7
	Shannon Co *	6	5.0	13.6	9.7
	St. Louis	6	2.9	10.3	6.8
Montana:	Glacier Nat. Pk *	6	2.7	6.9	5.2
	Helena	6	6.0	12.0	8.7
Nebraska:	Lincoln	7	3.1	10.9	6.9
	Omaha	6	3.9	12.1	6.9
	Thomas Co *	7	5.1	16.3	8.0
Nevada:	Las Vegas	5	6.1	23.6	14.7
	White Pine Co *	6	6.4	13.8	9.2
New Hampshire:	Coos Co *	7	3.1	8.6	6.4
	Manchester	5	4.4	8.9	6.2
New Jersey:	Camden	6	1.8	9.2	6.0
	East Orange	6	0.6	8.7	5.6
	Elizabeth	7	1.4	10.9	5.7
	Newark	6	1.5	7.2	4.5
	Trenton	6	1.7	9.0	5.6
New Mexico:	Albuquerque	7	5.5	15.4	10.0
	Colfax Co *	6	6.0	17.0	10.1
New York:	Cape Vincent *	5	6.3	9.1	7.6
	Elmira	6	4.0	9.0	6.3
	Glen Cove	2	6.6	8.6	7.6
	Massena	6	1.2	8.2	4.4
	Mt. Vernon	5	6.2	15.7	9.2
	New Rochelle	6	1.9	8.7	5.6
	New York	7	2.9	10.2	7.6
	Rochester	6	1.0	9.2	5.8
	Troy	4	1.1	9.8	6.4
North Carolina:	Asheville	5	3.0	12.6	6.7
	Cape Hatteras *	6	6.0	14.1	9.5
	Charlotte	4	5.7	10.7	8.9
	Winston Salem	6	2.5	19.1	9.6
North Dakota:	Bismarck	6	1.9	11.0	5.4
	Ward Co *	6	2.2	7.2	5.1
Ohio:	Akron	7	2.6	12.5	6.6
	Cincinnati	5	2.1	14.8	7.0
	Cleveland	6	4.7	10.0	7.6
	Columbus	6	2.2	15.7	7.3
	Dayton	6	2.2	13.1	6.5
	Lorain	7	2.8	11.0	6.9
	Springfield	7	3.9	11.4	7.2
	Toledo	6	5.7	10.0	7.2
	Youngstown	7	4.6	10.3	7.6
Oklahoma:	Cherokee Co *	6	6.0	15.4	10.1
	Oklahoma City	7	7.6	13.4	19.1
	Tulsa	5	5.6	9.0	7.6
Oregon:	Curry Co *	6	0.5	4.7	2.0
	Portland	5	0.9	12.8	5.1
Pennsylvania:	Clarion Co *	5	4.6	16.1	7.6
	Harrisburg	5	0.7	10.0	6.6
	Lancaster	5	2.7	27.0	10.6
	Philadelphia	7	2.4	9.5	6.0
	Pittsburgh	6	1.9	11.4	6.7
	Reading	6	4.7	8.1	6.4
	Wilkes Barre	6	3.0	10.9	7.2
Puerto Rico:	Loquillo Mtns *	5	2.1	9.9	4.3
	San Juan	5	2.0	7.8	4.1
Rhode Island:	Providence	6	6.7	10.7	8.0
	Washington Co *	7	0.5	6.9	4.9
South Carolina:	Columbia	4	6.6	12.3	9.5
	Greenville	7	4.1	12.7	9.2
	Richland Co *	6	3.1	12.6	7.3

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TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, SECOND QUARTER 1962—Con.

[Concentrations in pc/m³]

Station location		No. of samples	Minimum	Maximum	Average
South Dakota:	Black Hills Frst *	6	4.2	11.2	6.6
	Sioux Falls	6	0.6	7.6	4.0
Tennessee:	Chattanooga	5	3.4	11.2	5.6
	Memphis	6	4.5	11.8	6.6
	Nashville	7	5.0	17.3	8.3
Texas:	Aransas Co *	5	1.6	13.1	5.9
	Corpus Christi	5	3.7	11.3	6.0
	Dallas	6	2.4	15.4	9.5
	El Paso	7	7.2	15.8	11.5
	Ft. Worth	6	3.4	8.2	5.0
	Houston	6	3.5	9.5	6.0
	San Antonio	4	1.8	7.2	4.0
	Waco	7	2.5	10.0	6.6
Utah:	Salt Lake City	7	5.3	15.9	10.3
Vermont:	Burlington	5	1.2	8.0	5.0
	Orange Co *	7	0.5	11.0	7.9
Virginia:	Danville	6	7.6	13.3	9.2
	Norfolk	5	5.2	10.9	7.1
	Shenandoah Nat. Pk *	7	2.3	10.8	6.1
Washington:	Clallam Co *	7	0.9	13.1	3.7
	Seattle	5	0.7	3.9	1.9
	Tacoma	5	0.6	5.2	3.0
West Virginia:	Charleston	7	2.7	9.4	6.3
	Huntington	5	4.4	10.0	6.1
Wisconsin:	Door Co *	3	4.0	7.1	5.5
	Milwaukee	4	2.6	7.2	5.2
	Racine	6	1.8	5.6	4.0
Wyoming:	Cheyenne	7	5.3	16.7	9.2
	Yellowstone Pk *	7	5.5	17.5	9.8

*Nonurban station

Gross Beta Activity In Precipitation

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. The collection stations are located at Weather Bureau offices or airport stations. Monthly composite samples of precipitation are collected at 29 stations and forwarded to the Network laboratory for analysis.

Samples are analyzed for total solids and a large number of metals and nonmetals. In addition, samples are analyzed for fission product gross beta radioactivity if a large enough volume remains after the requirements for the chemical analysis have been met. Second quarter 1962 data are presented in table 5.

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, NASN, SECOND QUARTER 1962

Station		April		May		June	
		pc/liter	nc/m²	pc/liter	nc/m²	pc/liter	nc/m²
Alabama	Montgomery	910	140	—	—	890	11[illegible]
Florida	Tampa	*—	—	1030	66	439	3[illegible]
Illinois	Chicago, (Midway)	—	—	1910	83	1170	65
Illinois	Chicago, (O'Hare)	—	—	2280	168	—	—
Louisiana	Lake Charles	—	—	—	—	504	66
Maine	Caribou	2010	85	1490	70	1180	60
Massachusetts	Nantucket	1190	107	—	—	474	43
Michigan	Sault Ste. Marie	1470	64	875	105	—	—
Minnesota	St. Cloud	—	—	1480	130	1830	115
Montana	Glasgow	—	—	1140	66	1160	76
Nebraska	Grand Island	—	—	1980	167	843	53
New York	Albany	1130	48	2010	95	—	—
North Carolina	Cape Hatteras	795	93	—	—	291	64
Ohio	Cincinnati (Airport)	—	—	1270	101	876	65
	Cincinnati (Gest St.)	—	—	1550	77	1010	87
Pennsylvania	Philadelphia	1300	97	2330	101	4[illegible]9	80
South Carolina	Charleston	2300	100	—	—	271	92
South Carolina	Greenville	1030	144	—	—	546	96
Tennessee	Nashville	785	114	—	—	643	107
Texas	Amarillo	—	—	—	—	1880	288
Texas	Brownsville	—	—	967	42	265	21
Texas	San Angelo	2460	148	—	—	—	—
Virginia (Wash. D.C.)	Sterling	2700	124	1750	76	521	45
Washington	Tatoosh	870	157	—	—	—	—

* Dash denotes no sample.

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
First Quarter 1962

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division, Department of National Health and Welfare, Dominion of Canada, conducts air and precipitation sampling programs. The 24 air and precipitation stations are located at airports, and the equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport.

Air

About 650 cubic meters of air are drawn through a high efficiency 4-inch diameter filter during a 24-hour period. Filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. A 2-inch diameter disk is removed from each filter and counted with a thin end-window Geiger flow counter system, cali-

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RFSP, FIRST QUARTER 1962

[Average concentration in $\mu\mu c/m^3$]

Station location	January	February	March	Station location	January	February	March
Calgary	8.9	7.6	9.0	Resolute	2.2	[a]—	9.6
Chatham	8.4	8.9	6.2	Saskatoon	7.9	6.3	6.0
Coral Harbour	6.0	5.6	5.2	Shearwater	10.3	8.9	6.2
Edmonton	9.7	7.8	6.4	Torbay	7.8	4.1	—
Ft. Churchill	4.8	5.1	5.6	Toronto	9.4	9.3	8.4
Ft. William	8.9	7.9	8.0	Vancouver	6.1	10.9	6.6
Fredericton	8.7	9.8	6.0	Whitehorse	6.5	9.4	7.9
Goose Bay	5.9	6.7	4.7	Windsor	9.3	8.8	9.5
Inuvik	8.0	7.8	6.2	Winnipeg	8.6	7.2	7.4
Kapuskasing	8.2	8.4	9.7	Yellowknife	7.3	6.2	6.9
Montreal	8.5	7.2	7.5	Maximum station ave	10.3	10.9	9.7
Moosonee	8.2	7.7	9.4	Minimum station ave	2.2	4.1	4.7
Ottawa	9.2	7.7	8.5	Overall average	7.8	7.6	7.3
Regina	8.7	6.7	6.9				

[a] Dash denotes no sample.

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, FIRST QUARTER 1962

Station location	January		February		March	
	Concentration $\mu\mu c$/liter)	Deposition ($m\mu c/m^2$)	Concentration ($\mu\mu c$/liter)	Deposition ($m\mu c/m^2$)	Concentration ($\mu\mu c$/liter)	Deposition ($m\mu c/m^2$)
Calgary	1030	12.1	467	5.2	1460	15.2
Chatham	751	48.8	2040	48.8	751	55.0
Coral Harbour	[a] tr	14.5	tr	7.7	2430	21.0
Edmonton	1560	39.2	923	35.8	1340	34.1
Fredericton	739	47.1	812	56.3	2830	77.5
Ft. Churchill	70	12.5	1310	5.7	—	—
Ft. William	2240	33.0	885	50.7	2700	40.5
Goose Bay	328	16.2	391	19.7	874	64.7
Inuvik	675	20.9	873	21.9	918	11.0
Kapuskasing	458	18.3	272	7.9	1120	24.2
Montreal	3020	118.8	1490	114.4	1260	84.6
Moosonee	[b]—	—	—	—	806	28.0
Ottawa	1100	62.6	638	41.1	1080	50.6
Regina	2510	45.2	2420	31.3	1690	32.3
Resolute	tr	52.0	tr	96.7	tr	56.0
Saskatoon	2990	45.5	909	36.8	876	16.9
Shearwater	—	—	1090	171.5	1090	57.9
Torbay	505	53.1	648	140.0	1020	150.0
Toronto	1950	107.8	1520	113.3	2870	29.1
Vancouver	—	—	565	36.1	768	71.8
Whitehorse	927	24.7	2380	23.5	789	18.6
Windsor	1590	87.7	1690	133.1	1420	36.7
Winnipeg	1550	34.3	793	31.6	1380	41.6
Yellowknife	602	17.3	471	6.0	128	8.4
Average	1290	43.4	1080	53.7	1340	44.6

[a] tr denotes trace precipitation.
[b] Dash denotes no sample.

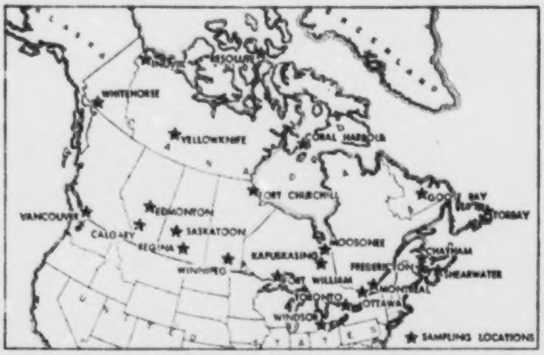
INUVIK
RESOLUTE
WHITEHORSE
YELLOWKNIFE
CORAL HARBOUR
FORT CHURCHILL
GOOSE BAY
TORBAY
VANCOUVER
EDMONTON
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
KAPUSKASING
FREDERICTON
CHATHAM
SHEARWATER
FORT WILLIAM
MONTREAL
OTTAWA
TORONTO
WINDSOR
SAMPLING LOCATIONS

FIGURE 6.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

brated with a Sr^{90}–Y^{90} standard. The delay period between collection and counting is one week to avoid interference from naturally-occurring radon and thoron daughters. Air data for first quarter 1962 are presented in table 6.

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. First quarter precipitation data are presented in table 7.

More detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's annual reports for 1959 and 1960 (*1*, *2*).

REFERENCES

(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW (RP-3)*, (May 1960).

(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW (RP-4)*, (December 1961).

Previous coverage in *Radiological Health Data*:

Period	Issue
July 1959–June 1960	*January 1961*
Third quarter 1960	*April 1961*
Fourth quarter 1960	*August 1961*
First quarter 1961	*December 1961*
Second quarter 1961	*February 1962*
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*

Natural and Fission Product Radioactivity in Surface Air Particulates at Cincinnati, Ohio

June 18–July 13, 1962

Division of Radiological Health, Public Health Service

The determination of natural radioactivity in the atmosphere is useful because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Some of the more important examples of naturally occurring and artificially produced airborne radioactivity are given in table 1. The physical state is of importance in the selection of sampling procedure.

TABLE 1.—EXAMPLES OF AIRBORNE RADIOACTIVITY

Physical state	Natural		Artificial
	Nuclides (radiation)	α half life	
Gaseous	Radon (α, γ) Thoron (α, γ)	3.8 days 54 seconds	Some fission products (β, γ)
Particulates	Radon daughters (α, β, γ) Thoron daughters (α, β, γ)	0.5 hours 10.6 hours	Most fission products (β, γ)

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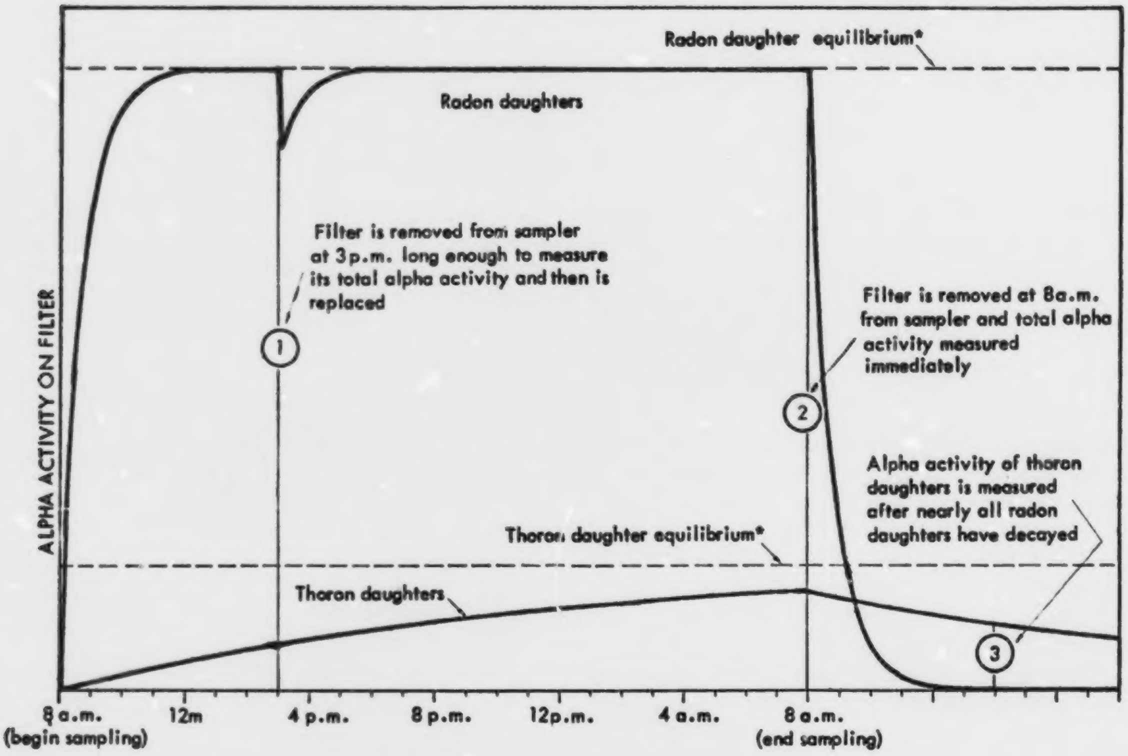

* Equilibrium values do not in fact remain constant throughout a 24-hour period but vary with changes of radon and thoron concentrations in air.

FIGURE 1.—IDEALIZED PROFILE OF ALPHA ACTIVITY ON FILTER DURING AND AFTER SAMPLING

Radon and Thoron

The earth's crust contains trace amounts of naturally-occurring uranium and thorium, each of which decays through a series of radionuclides, ending finally in stable isotopes of lead. One of the radionuclides in the uranium series is the inert gas, radon–222, commonly called "radon." In the thorium series, the inert gas decay product is radon–220, or "thoron." Some radon and thoron gases formed near the ground surface escape into the atmosphere before decaying to their particulate daughter products. Concentrations of radon and thoron in surface air depend on prevailing atmospheric conditions such as ambient temperature, wind, and pressure and on soil conditions such as moisture, porosity, and temperature that affect the rate of diffusion of the gases through the soil.

Most of the natural radioactivity in surface air is due to radon and its daughters. Thoron and its daughters contribute less because of thoron's shorter half life, and therefore, less time for diffusion through the pores of the soil to escape into the atmosphere. The natural radioactivity concentration in air shows a pronounced daily fluctuation. During a period of atmospheric inversion, such as often occurs in the early morning, radon and thoron tend to accumulate in the air near the ground surface. During periods of atmospheric turbulence, radon and thoron are dispersed in the atmosphere, leaving lower concentrations near the surface.

Measurement of radon and thoron concentrations in air may be accomplished by two general methods. The direct method involves the collection of radon and thoron gases by charcoal adsorption (*1*) while the indirect method utilizes the collection of airborne particulates,

TABLE 2.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS AT CINCINNATI, OHIO, JUNE 18–JULY 13, 1962

End of sampling period		Rn^{222} 8 a.m. ($\mu\mu c/m^3$)	Rn^{222} 3 p.m. ($\mu\mu c/m^3$)	Rn^{220} ($\mu\mu c/m^3$)	Beta activity ($\mu\mu c/m^3$)
June 18		880	160	3.0	9.53
19		240	150	1.8	6.89
20		460	140	4.8	7.21
21		620	130	6.8	5.55
22		440	200	5.4	8.65
25		700	160	4.2	5.63
26		770	160	6.7	9.10
27		410	240	4.7	7.80
28		240	110	9.6	7.16
29		610	140	6.5	7.93
July 2		600	190	6.7	7.48
3		260	200	2.9	5.72
5		480	200	3.3	1.91
6		500	190	3.5	1.41
9		250	70	3.5	2.98
10		690	120	5.4	3.24
11		670	160	6.7	5.21
12		250	130	3.1	4.87
13		500	170	5.4	4.94
Average		532	156	4.7	5.94
Range of counting errors (2σ)	Maximum	52	27	1.0	0.18
	Minimum	27	15	0.4	0.06

which include the radon and thoron daughter products, on the surface of a membrane filter. The choice of the indirect method for routine monitoring was made because of simplicity, sensitivity, and low cost.

The measurement of radon and thoron by the indirect method is based on the assumption that radon and thoron in the atmosphere are in equilibrium with their daughters. Under these conditions the particulate alpha activity (from the daughter products) retained on the membrane filter by a uniform flow of air may be theoretically related to the concentrations of radon and thoron in air. If radon and thoron activities in the air remain constant, the alpha activity on the filter while the sampler is in operation will reach 97 percent of equilibrium in 2.5 hours for radon daughters and in 53 hours for thoron daughters. The measurement of the activity by alpha scintillation, which is specific for alpha activity, eliminates interference from fission product beta activity.

The method used for the separate measurements of radon and thoron daughters is diagrammed in figure 1 where the history of one filter during a typical 24-hour sampling period and for a period following its removal is charted. At 3:00 p.m. the filter is removed momentarily from the sampler and counted. Although some thoron daughter activity is present, it is neglected and the activity is taken as radon daughter activity. The time of 3:00 p.m. was selected to represent the time of day most likely to have atmospheric turbulence and, therefore, lowest radon concentration in surface air. Radon and thoron concentrations often reach a maximum during an early morning atmospheric inversion condition. The 8:00 a.m. measurement of activity therefore approximates the daily maximum.

The measured alpha activities are adjusted to 100 percent equilibrium with factors based on length of sampling period and decay time after removal of filter. (*2*) The equilibrium alpha activities on the filter due to the respective daughter products may in turn be converted to radon and thoron concentrations in air by the following expressions:

$$\text{radon } (\mu\mu c/m^3) = 6\ A_r/F, \text{ and}$$

$$\text{thoron } (\mu\mu c/m^3) = 0.45\ A_t/F,$$

where A_r and A_t are the radon and thoron daughter alpha activities (dpm) respectively and F is the air sampling rate in liters per minute at the end of the sampling period.

Table 2 shows daily calculated radon activities for 8 a.m. and 3 p.m. and thoron for 8 a.m.

Fission Product Activity

The membrane filter used for the determination of radon and thoron is retained several days to allow for the decay of thoron daughters. At that time the beta activity is measured. This activity represents fission products and is reported in table 2.

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SECTION II.—FOOD

Strontium–90 Concentrations in U.S. Wheat and Milling Products[1]

1960

J. Rivera
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Concentrations of strontium–90 and calcium in U.S. wheat and milling products have been studied extensively at the Health and Safety Laboratory (HASL) since 1958. Table 2 compares the results of the survey of the 1960 crop with those previously published for the 1958 and 1959 crops. A pictorial representation of the data for 1959 and 1960 is presented in figure 1. Each cube, scaled to represent the concentration, is placed on the appropriate state. Material balances for the milling products are given in table 3, and new information on the 1960 milling products[2] is summarized in table 4. These data show a remarkable similarity in the relative distributions of strontium–90 among the different milling fractions. Moreover, this distribution pattern appears to have persisted over the three year period, in spite of the fact that fallout conditions varied considerably. The logical conclusion is that most of the strontium–90 found in wheat originated from a single source.

TABLE 1.—STRONTIUM-90 DEPOSITION IN WHEAT AND SOIL

Year	Wheat ($\mu\mu c\ Sr^{90}/g\ Ca$)	Soil Description	
		Cumulative ($m\mu c\ Sr^{90}/m^2$)	($m\mu c\ Sr^{90}/m^2$) in June
1958	172*	18	0.58
1959	147*	26	0.57
1960	62	27	0.20

* Assuming 0.36 g Ca/kg of wheat.

Strontium–90 in wheat is derived either from the soil by root extraction or through direct deposition on foliar surfaces. Minimum estimates of strontium–90 in wheat from the latter source have been made by comparing the specific activity ($\mu\mu c\ Sr^{90}$/mg stable Sr) of flour with that of bran and assuming that the strontium–90 in the flour is derived solely from

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[1] U.S. Atomic Energy Commission: *Summary Quarterly Reports, HASL–122*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1962), price $3.00.

[2] The production of flour from wheat grain is accomplished through milling. The first stage in this process involves the flattening and splitting of the kernels and the removal of the wheat *germ* which is not utilized in the production of flour. The grain is then passed through a series of rollers which remove successive layers of cells from the kernel. The highest grade flour is made mostly from the innermost part of the kernel and is called *patent flour*. Flour of lower quality is made from layers of cells nearer to the surface of the kernel, this flour is called the *first or second clear*. The outermost part of the wheat berry which forms a coat which is relatively easily removed is called the *bran*. Bran is not used in making flour. *Shorts* consists mainly of fine particles of bran mixed with some clear flour.

TABLE 2.—COMPARISON BETWEEN STRONTIUM-90 AND CALCIUM LEVELS IN UNITED STATES WHEAT SAMPLED IN 1958, 1959, AND 1960

State	Calcium			Strontium-90					
	(g/kg)			($\mu\mu c$/kg)			($\mu\mu c$/g Ca)		
	1958	1959	1960	1958	1959	1960	1958	1959	1960
California	[a]—	0.34	0.33	—	17	3.7	—	49 (2)[b]	11 (5)
Colorado	—	0.49	0.42	—	46	19	—	71 (5)	46 (2)
Idaho	—	0.34	0.35	—	5.7	6.1	—	17 (1)	18 (2)
Illinois	0.40	0.38	—	133	54		330 (1)	142 (1)	—
Iowa	—	0.54	0.38	—	62	34	—	109 (2)	89 (1)
Kansas	0.36	0.49	0.42	82	47	26	227 (1)	97 (1)	62 (1)
Michigan	0.36	0.38	—	42	48	—	118 (1)	125 (1)	—
Minnesota	0.35	0.33	—	51	59	—	162 (16)	181 (2)	—
Missouri	—	0.43	0.42	—	121	21	—	272 (4)	50 (1)
Montana	0.47	0.38	0.40	59	20	15	125 (1)	52 (1)	38 (1)
Nebraska	—	0.48	0.37	—	76	32	—	159 (3)	68 (3)
New York	0.36	0.37	0.41	44	44	16	121 (1)	119 (1)	40 (1)
North Dakota	0.31	0.33	0.29	40	51	26	134 (10)	154 (1)	91 (1)
Ohio	—	0.36	0.48	—	56	35	—	152 (11)	73 (4)
Oklahoma	0.41	0.40	0.39	34	63	35	82 (1)	159 (1)	90 (2)
South Dakota	0.35	—	—	61	—	—	171 (8)	—	—
Texas	0.44	0.51	—	44	51	—	99 (2)	99 (1)	—
Utah	—	0.48	0.44	—	21	7.9	—	45 (5)	19 (4)
Washington	—	0.32	0.35	—	9.2	7.0	—	30 (2)	20 (1)

[a] Dash indicates no sample.

[b] Numbers in parentheses indicate number of samples averaged.

the soil by root uptake (*1*). The inaccuracy of this assumption is apparent from the data presented in table 3. Despite the fact that the strontium-90 levels in soil probably increased in 1960 as compared to 1959, the strontium-90 concentration in patent flour decreased sharply. It follows that much of the strontium-90 in the patent flour was derived by translocation of strontium-90 directly deposited on the outer parts of the grain. This translocation effect should be more easily seen in 1962 by tracing fresh fallout expected to be found in wheat through Sr^{89}/Sr^{90} ratios in the milling fractions. Presumably this will be possible since it is expected that the 1962 wheat crop will be contaminated by fresh fallout from the Soviet test series that were held in late 1961.

The concentration of strontium-90 in wheat grown in the United States was estimated to be 62 ± 27 $\mu\mu c$/kg in 1958; 53 ± 19 $\mu\mu c$/kg in

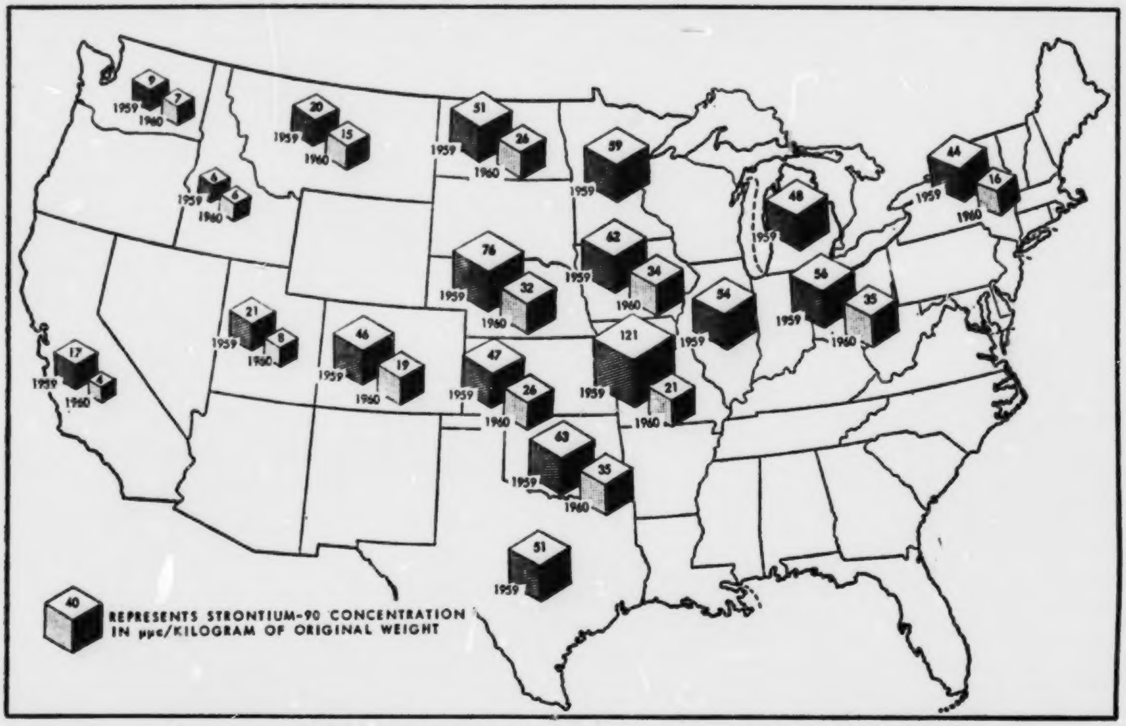
TABLE 3.—STRONTIUM-90 MATERIAL BALANCE IN UNITED STATES WHEAT AND MILLING PRODUCTS

Material	Weight (kg)	[a]1958		[b]1959		[c]1960	
		$\mu\mu c$/kg	$\mu\mu c$ in fraction	$\mu\mu c$/kg	$\mu\mu c$ in fraction	$\mu\mu c$/kg	$\mu\mu c$ in fraction
Input: Wheat	100	62	6200	53	5300	28	2800
Output: Patent Flour	58	12	696	9	522	4	232
1st & 2nd Clear	14	28	392	17	238	9	126
Germ & Shorts	17	133	2261	143	2431	66	1122
Bran	11	231	2541	163	1793	107	1177
Output total	100		5890		4984		2657
Difference			310 (5%)		316 (6%)		143 (5%)

[a] Production weighted average of 9 states.

[b] Production weighted average of 5 states representing 64 percent of 1958 production, *The World Almanac and Book of Facts for 1960*.

[c] Production weighted average of 6 states representing 55 percent of 1960 production, *The World Almanac and Book of Facts for 1962*.


9
1959
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121
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17
1959
4
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47
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26
1960
63
1959
35
1960
51
1959
40
REPRESENTS STRONTIUM-90 CONCENTRATION IN μμc/KILOGRAM OF ORIGINAL WEIGHT

FIGURE 1.—STRONTIUM-90 IN U.S. WHEAT HARVESTED IN 1959 & 1960

TABLE 4.—STRONTIUM-90 AND CALCIUM IN WHEAT AND MILLING PRODUCTS 1960

State	Wheat	Bran	Germ	Shorts	Clear	Patent
μμc Sr⁹⁰/kg:						
Kansas	26	111	49	97	9.4	4.6
Montana	15	70	70	49	4.5	3.3
Nebraska	32	115	60	26	8.8	4.9
North Dakota	26	102	42	76	7.2	3.8
Ohio	31	95	37	56	12	5.4
Oklahoma—(80%), Texas—(20%)	44	138	61	110	11	3.8
μμc Sr⁹⁰/g Ca:						
Kansas	62	78	67	90	43	22
Montana	38	81	159	58	30	36
Nebraska	85	125	108	23	35	31
North Dakota	90	111	81	87	48	34
Ohio	78	68	61	80	46	36
Oklahoma—(80%), Texas—(20%)	113	141	95	119	38	20
g Ca/kg:						
Kansas	0.42	1.4	0.74	1.1	0.22	0.21
Montana	0.40	0.86	0.42	0.87	0.15	0.09
Nebraska	0.37	0.92	0.56	1.1	0.25	0.16
North Dakota	0.29	0.93	0.52	0.87	0.15	0.11
Ohio	0.41	1.4	0.61	0.70	0.26	0.15
Oklahoma—(80%), Texas—(20%)	0.39	0.97	0.63	0.94	0.29	0.19

1959; and 24 ± 9 μμc/kg in 1960.[3] While the difference between the 1958 and 1959 concentrations was not statistically significant, the difference between the 1959 and 1960 concentrations is significant. Since the level of strontium-90 in the soil increased between 1959 and 1960, the decline in the concentration of strontium-90 in wheat grown in 1960 must have been due to a decline in the fallout rate and a consequent decrease in direct deposition of strontium-90 on the grain.

Middleton has shown that wheat is most

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[3] Weighted average of 14 states representing 73 percent of 1960 production. *The World Almanac and Book of Facts for 1962.* The error terms given for strontium-90 concentrations in U.S. wheat are one standard deviation from the production weighted average.

likely to be contaminated by direct deposition after the emergence of the ears from the boot (*2*). For the majority of wheat harvested in the United States, this occurs in June (*3*). The fallout rate in June for the midwestern wheat producing states can be estimated from the HASL monthly pot and funnel monitoring network. The cumulative deposit of strontium–90 in the soils of these states can also be estimated from the HASL-USDA soil sampling program. These estimates, together with the Sr^{90}/Ca ratio in wheat for 1958, 1959 and 1960, are shown in table 1.

From these data in table 1 we can find suitable values for proportionality factors "a" and "b" in an expression of the form,

$$V = a\,S + b\,R$$

where V is the Sr^{90}/Ca ratio in the wheat, S is the cumulative deposit of strontium–90 in the soil, and R is the fallout rate. A choice of "a" and "b" that fit the data reasonably well is, a = 0.12 μμc/g Ca/mc/mi^2 and b = 102 μμc/g Ca/mc/mi^2 deposited in June. Using these values for "a" and "b," the fraction of the Sr^{90}/Ca ratio in wheat due to direct deposition was about 90 percent for all three years. This result is in good agreement with the estimate of Menzel, et al. (*4*) for wheat grown in Maryland in 1959.

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(*2*) Middleton, L. J.: Radioactive Strontium and Cesium in the Edible Parts of Crop Plants after Foliar Contamination, *International Journal of Radiation Biology, 1:387* (October 1959).

(*3*) Private Communication, L. W. Briggle: U.S. Department of Agriculture, Beltsville, Maryland.

(*4*) Menzel, R. G., et al: Foliar Retention of Strontium–90 by Wheat, *Science, 134*:559-60 (August 25, 1961).

Previous coverage of wheat data in *Radiological Health Data:*

Period	Issue
1958–1959	*May 1960*
1958–1960	*October 1960*
1958–1959	*November 1960*
1958–1959	*April 1961*
1959 (foreign)	*April 1961*
1958–1959 (Canadian)	*July 1961*
1960	*January 1962*

Deposition of Strontium–90 in a 1960 Kansas Wheat Sample[1]

J. Rivera

Health and Safety Laboratory, U.S. Atomic Energy Commission

Knowledge of the mechanism by which plants are contaminated by fallout is essential for the accurate prediction of future levels of strontium–90 in foods. A particularly important fact that must be known is whether plants become contaminated principally from strontium–90 that is absorbed from the soil or from strontium–90 that results from the direct deposition of fallout on the plant surfaces. The experiment presented here on the contamination of wheat may be of some help in resolving this problem.

A sample of wheat from Kansas harvested in 1960 was treated in such a way as to remove the epidermal layer of the bran coats. The resulting two fractions, together with an aliquot of the original wheat sample, were analyzed for strontium–90 and stable strontium. The results are presented in table 1.

If all of the strontium–90 in the wheat berry were derived from the soil, then the specific activity (μμc Sr^{90}/mg Sr) in each of the fractions of the berry would be the same. The outermost part of the berry, however, was exposed to direct deposition of strontium–90 from fallout in addition to that which was derived from the soil. If there had been no direct deposition of strontium–90 on the "beeswing," it would have had the same specific activity as the inner part of the berry, namely, 5.69 μμc Sr^{90}/mg Sr, and would have contained 5.69 × 0.71 = 4.00 μμc Sr^{90}. Since the observed amount of strontium–90 in this fraction was 7.1 μμc, the difference of 3.1 μμc could be attributed to direct deposition.

The strontium–90 in the stripped fraction of the wheat may not have originated entirely from strontium–90 in the soil as was assumed here, but rather some may have come from

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[1] U.S. Atomic Energy Commission: *Summary Quarterly Report, HASL–127*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1962), price $3.00.

TABLE 1.—STRONTIUM IN WHEAT FRACTION

Wheat fraction	$\mu\mu c$ Sr^{90}/kg	kg in fraction	$\mu\mu c$ Sr^{90} in fraction	mg Sr/kg	mg Sr in fraction	Specific activity ($\mu\mu c$ Sr^{90}/mg Sr)
Wheat	26.1	1.000	26.1	4.02	4.02	6.49
Stripped wheat	19.6	0.968	19.0	3.45	3.34	5.69
Beeswing *	216.4	0.033	7.1	21.57	0.71	10.00

* Fraction stripped from wheat.

strontium–90 that was directly deposited on the outer part of the berry and then translocated to the inner part. The estimate that 4.00 μμc Sr^{90} in the "beeswing" came from the soil is, therefore, a maximum estimate and 3.1 μμc must, therefore, be regarded as the minimum amount that was due to direct deposition.

There is considerable evidence to the effect that the amount of strontium–90 directly deposited on the wheat berry is proportional to the fallout rate (see page 392). One would expect, therefore, that the fraction of strontium–90 in wheat due to direct deposition would have been greater in a sample harvested in 1959 than one harvested in 1960 since the fallout was greater in 1959 than in 1960.

An experiment identical to the one described above was performed on a sample of Kansas wheat harvested in 1959 (*1*). The result was that an estimated 22 percent of the total strontium–90 in the wheat was the minimum amount that was ascribable to the direct deposition. The minimum amount of strontium–90 in the wheat due to direct deposition for the 1960 sample of 3.1 μμc was 12 percent of the total in the sample. These results substantiate the belief that direct deposition constitutes a very important factor in the contamination of wheat with strontium–90 from fallout.

REFERENCE

(*1*) Rivera, J.: Distribution of Strontium–90 in a 1959 Wheat Sample, *Science*, *133*:755–6 (March 17, 1961).

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SECTION III.—MILK

Radionuclide Analyses of Pasteurized Milk

PASTEURIZED MILK MONITORING PROGRAM
June 1962

Division of Radiological Health
Division of Environmental Engineering and Food Protection
Public Health Service

Milk monitoring has been conducted by the Public Health Service since early 1957 when the first program was established to develop suitable sampling methods and radiochemical analytical procedures. Milk is produced every day throughout the year in practically every county of the United States. It can be readily checked in processing centers and is a good indicator of fallout in the diet. Raw milk was initially selected for investigation; however, it became evident that the milk actually consumed by the population should be included in a broader sampling program. The result was the initiation, in the first quarter of 1960, of a pasteurized milk sampling program designed to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in the pasteurized milk monitoring.

The June 1961 raw milk sampling results, reported in the November 1961 *Radiological Health Data* (*RHD*), represent the last regular publication of such data. A summary discussion of the raw milk sampling program in the December 1961 *RHD* presented the gross relationship between fallout and the occurrence of fission products in milk determined from this study.

During June 1962, the surveillance of pasteurized milk was conducted at 61 stations with the cooperation of State and local milk sanitation agencies who have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis (see figure 1). Publication in *RHD* follows about 3½ months after sample collection because of time required for shipment, processing, decay-product buildup, data compilation, and publication procedures.

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all states and additional points

22<

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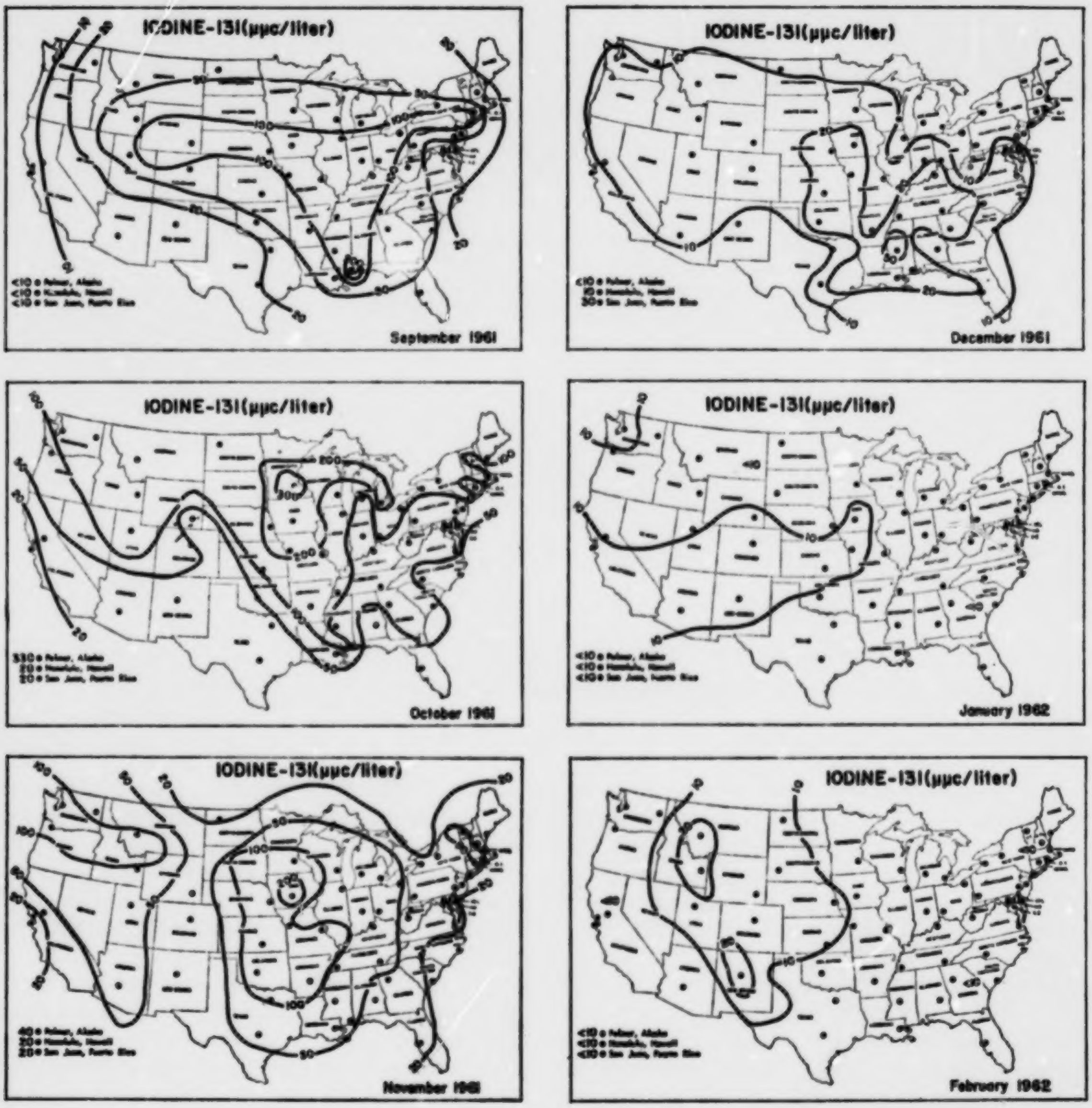

IODINE-131(μμc/liter)
<10 • Palmer, Alaska
<10 • Honolulu, Hawaii
<10 • San Juan, Puerto Rico
September 1961
IODINE-131(μμc/liter)
<10 • Palmer, Alaska
10 • Honolulu, Hawaii
30 • San Juan, Puerto Rico
December 1961
IODINE-131(μμc/liter)
330 • Palmer, Alaska
20 • Honolulu, Hawaii
20 • San Juan, Puerto Rico
October 1961
IODINE-131(μμc/liter)
<10 • Palmer, Alaska
<10 • Honolulu, Hawaii
<10 • San Juan, Puerto Rico
January 1962
IODINE-131(μμc/liter)
40 • Palmer, Alaska
20 • Honolulu, Hawaii
20 • San Juan, Puerto Rico
November 1961
IODINE-131(μμc/liter)
<10 • Palmer, Alaska
<10 • Honolulu, Hawaii
<10 • San Juan, Puerto Rico
February 1962

FIGURE 1.—IODINE-131 CONCENTRATION CONTOURS AND MILK SAMPLING STATIONS

when indicated by widely varying conditions of the milk supply or the need to cover large population groups. Each sample is composited in proportion to the volume of milk produced by those plants supplying not less than 90 percent of a city's milk supply. Prior to September 15, 1961, this composite sample was taken from one day's production of pasteurized milk per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling schedule has been increased in frequency. During June 1962, most stations were sampled twice a week. As all surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention and

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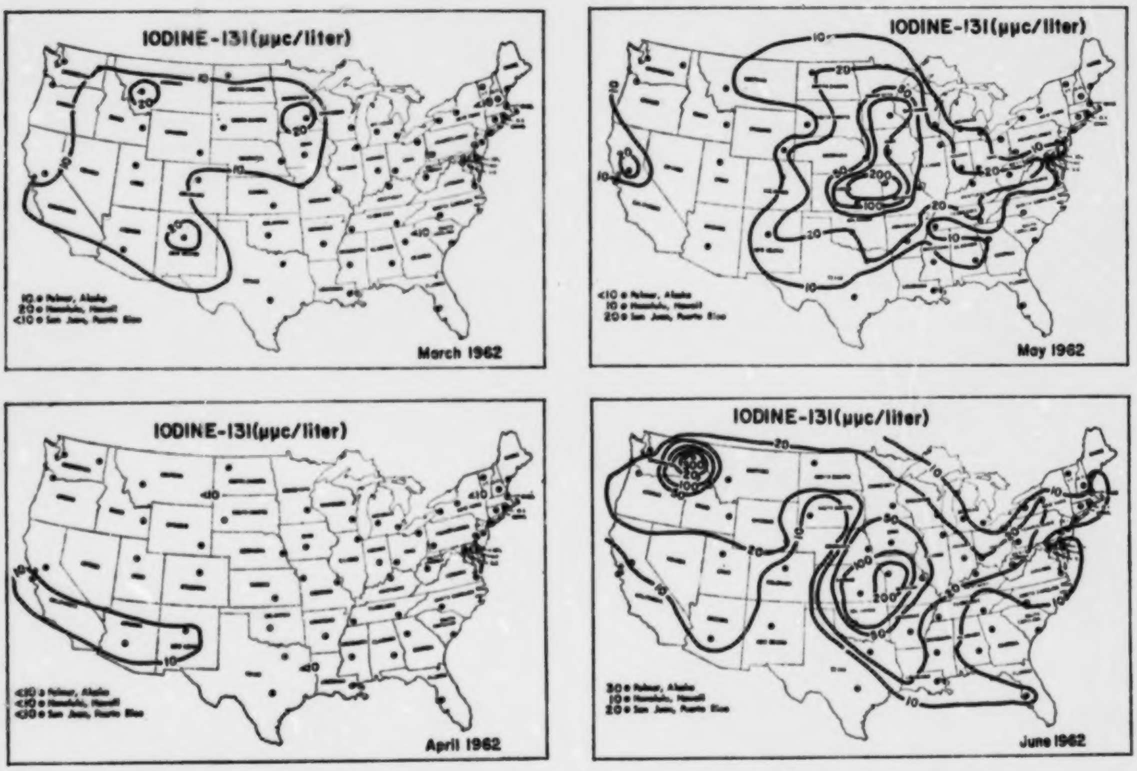
IODINE-131(μμc/liter)
10 ● Palmer, Alaska
20 ● Honolulu, Hawaii
<10 ● San Juan, Puerto Rico
March 1962
IODINE-131(μμc/liter)
<10 ● Palmer, Alaska
10 ● Honolulu, Hawaii
20 ● San Juan, Puerto Rico
May 1962
IODINE-131(μμc/liter)
<10 ● Palmer, Alaska
<10 ● Honolulu, Hawaii
<10 ● San Juan, Puerto Rico
April 1962
IODINE-131(μμc/liter)
30 ● Palmer, Alaska
10 ● Honolulu, Hawaii
20 ● San Juan, Puerto Rico
June 1962

FIGURE 1.—IODINE-131 CONCENTRATION CONTOURS AND MILK SAMPLING STATIONS—Continued

adjustment in the pasteurized milk sampling program operation, further atmospheric nuclear testing may require an immediate re-evaluation and readjustment of the sampling frequency and analytical schedule for this program.

Iodine-131, cesium-137, and barium-140 are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 are determined following radiochemical separation. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for June 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Iodine-131 Geographical Distribution

Just prior to September 1961, the iodine-131 concentrations in pasteurized milk were not detectable. Figure 1 geographically displays the average iodine-131 concentrations in pasteurized milk from September 1961 through June 1962. These plots are based on concentrations in pasteurized milk representing milk sold in 61 cities distributed throughout the United States. Intervening milk sheds for smaller cities or the effect on intra- and interstate milk distribution are not taken into consideration. This permits the use of concentration contours for geographically presenting these data.

During the first few months of 1962, the iodine-131 concentrations in pasteurized milk were not generally detectable, since the iodine-131 present in November and December 1961 had decayed to relatively low levels. In May and June 1962, the concentrations in pasteurized milk again increased due to nuclear

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, JUNE 1962

[Average radioactivity concentrations in μμc/liter]

Sampling location		Calcium (gm/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Strontium-90 profile in *RHD*
State	City	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	
Alabama	Montgomery	1.20	1.21	105	55	19	16	10	<10	55	50	20	20	Oct. 62
Alaska	Palmer	1.08	1.05	35	60	9	13	10	30	20	25	<10	10	
Arizona	Phoenix	1.09	1.12	15	5	3	3	<10	10	10	10	<10	10	Sept. 62
Arkansas	Little Rock	1.17	1.18	225	120	37	32	20	20	95	80	40	30	July 62
California	Sacramento	1.09	1.12	30	20	5	5	10	10	15	10	<10	<10	Aug. 62
California	San Francisco	1.10	1.07	55	25	9	7	<10	<10	15	10	10	<10	Oct. 62
Colorado	Denver	1.16	1.19	30	60	8	13	<10	<10	10	30	<10	<10	Aug. 62
Connecticut	Hartford	1.19	1.24	15	35	11	14	<10	10	35	70	<10	<10	Aug. 62
Delaware	Wilmington	1.20	1.22	50	40	15	17	10	20	50	80	<10	<10	Sept. 62
District of Columbia	Washington	1.15	1.14	50	65	15	17	<10	10	40	65	10	20	Oct. 62
Florida	Tampa	1.21	1.21	25	25	10	11	<10	10	105	120	<10	10	Sept. 62
Georgia	Atlanta	1.20	1.18	120	70	22	20	<10	<10	80	75	20	20	Oct. 62
Hawaii	Honolulu	1.08	1.08	30	25	5	5	<10	10	25	30	<10	10	
Idaho	Idaho Falls	1.09	1.12	25	50	7	13	10	30	20	45	10	10	Sept. 62
Illinois	Chicago	1.16	1.19	35	70	11	15	20	30	30	65	10	10	Oct. 62
Indiana	Indianapolis	1.20	1.22	50	60	15	16	20	30	40	50	20	20	Aug. 62
Iowa	Des Moines	1.08	1.09	95	170	15	26	60	70	25	40	20	20	Sept. 62
Kansas	Wichita	1.08	1.08	65	80	12	16	120	130	20	40	20	20	July 62
Kentucky	Louisville	1.17	1.16	115	120	21	25	20	20	40	60	20	30	Sept. 62
Louisiana	New Orleans	1.23	1.24	215	145	37	38	<10	10	135	110	30	30	June 62
Maine	Portland	1.22	1.24	20	45	12	13	<10	10	50	95	<10	<10	Sept. 62
Maryland	Baltimore	1.17	1.15	45	60	15	17	10	<10	50	70	10	20	Sept. 62
Massachusetts	Boston	1.16	1.13	20	45	13	16	<10	10	50	100	<10	<10	Oct. 62
Michigan	Detroit	1.17	1.18	25	40	11	14	<10	<10	30	55	<10	<10	Aug. 62
Michigan	Grand Rapids	1.23	1.21	20	40	10	12	<10	10	30	55	<10	10	Sept. 62
Minnesota	Minneapolis	1.08	1.10	60	115	13	24	50	30	30	65	10	10	Oct. 62
Mississippi	Jackson	1.26	1.25	220	140	33	29	<10	10	85	85	30	30	Aug. 62
Missouri	Kansas City	1.09	1.11	130	215	18	25	150	240	30	50	40	50	Aug. 62
Missouri	St. Louis	1.08	1.12	85	115	16	23	30	60	30	50	10	20	June 62
Montana	Helena	1.08	1.09	45	75	10	16	20	30	25	50	10	10	July 62
Nebraska	Omaha	1.14	1.00	70	130	13	24	40	80	20	40	10	20	Sept. 62
New Hampshire	Manchester	1.15	1.06	15	35	10	12	<10	<10	60	115	<10	<10	Sept. 62
New Jersey	Trenton	1.13	1.09	25	35	10	12	<10	<10	30	60	<10	<10	Aug. 62
New Mexico	Albuquerque	1.09	1.10	15	20	4	6	10	<10	<5	<5	10	<10	July 62
New York	Buffalo	1.16	1.12	20	40	10	13	<10	10	40	80	<10	<10	Aug. 62
New York	New York	1.13	1.14	20	40	12	14	10	10	40	85	<10	<10	Oct. 62
New York	Syracuse	1.17	1.21	20	30	10	12	20	20	25	50	<10	<10	July 62
North Carolina	Charlotte	1.22	1.23	95	90	22	27	<10	10	55	70	20	20	July 62
North Dakota	Minot	1.10	1.09	60	120	16	30	20	20	30	70	<10	<10	Sept. 62
Ohio	Cincinnati	1.18	1.21	65	70	17	19	20	20	30	50	20	20	Aug. 62
Ohio	Cleveland	1.15	1.15	35	60	11	14	<10	10	30	65	<10	<10	July 62
Oklahoma	Oklahoma City	1.15	1.14	115	135	21	29	60	160	60	95	30	50	Oct. 62
Oregon	Portland	1.13	1.14	95	65	17	14	10	30	55	65	10	<10	Aug. 62
Pennsylvania	Philadelphia	1.16	1.17	35	40	13	13	<10	10	45	75	<10	<10	July 62
Pennsylvania	Pittsburgh	1.17	1.18	35	55	14	17	10	30	45	90	<10	<10	June 62
Puerto Rico	San Juan	1.13	1.15	75	55	11	13	20	20	55	50	20	20	
Rhode Island	Providence	1.19	1.23	20	35	12	13	10	10	45	85	<10	<10	Sept. 62
South Carolina	Charleston	1.20	1.19	95	60	21	20	<10	<10	75	80	20	20	Aug. 62
South Dakota	Rapid City	1.09	1.19	70	185	17	40	<10	<10	30	85	10	<10	Oct. 62
Tennessee	Chattanooga	1.24	1.22	200	105	28	24	10	<10	90	70	30	20	Oct. 62
Tennessee	Memphis	1.21	1.20	160	115	27	26	<10	10	40	45	30	20	Sept. 62
Texas	Austin	1.17	1.14	35	30	8	8	<10	<10	25	40	<10	10	Oct. 62
Texas	Dallas	1.18	1.19	115	85	18	18	20	30	50	50	20	30	Aug. 62
Utah	Salt Lake City	1.11	1.12	25	40	8	14	<10	10	30	75	<10	10	June 62
Vermont	Burlington	1.13	1.10	15	30	10	13	<10	<10	30	55	<10	<10	Aug. 62
Virginia	Norfolk	1.19	1.19	70	70	17	21	<10	10	55	80	10	20	Aug. 62
Washington	Seattle	1.12	1.15	80	65	18	19	<10	10	55	75	<10	<10	Oct. 62
Washington	Spokane	1.13	1.16	55	85	14	18	120	350	35	55	<10	<10	Aug. 62
West Virginia	Charleston	1.17	1.14	80	115	18	23	20	20	35	60	20	30	Oct. 62
Wisconsin	Milwaukee	1.20	1.18	15	35	8	11	10	20	15	25	<10	<10	Sept. 62
Wyoming	Laramie	1.09	1.13	35	60	8	15	20	20	25	50	10	10	Sept. 62
Network average		1.15	1.16	65	71	14	17	20	30	40	61	10	14	

weapons testing. The highest June average iodine–131 concentration in pasteurized milk appeared at Spokane, Washington.

Strontium–90 Profiles

In previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from selected cities in the monitoring program were published. An additional 14 cities are presented in figure 2. Each graph shows the strontium–90 concentrations in milk from selected cities in 4 geographic regions of the United States. The usual

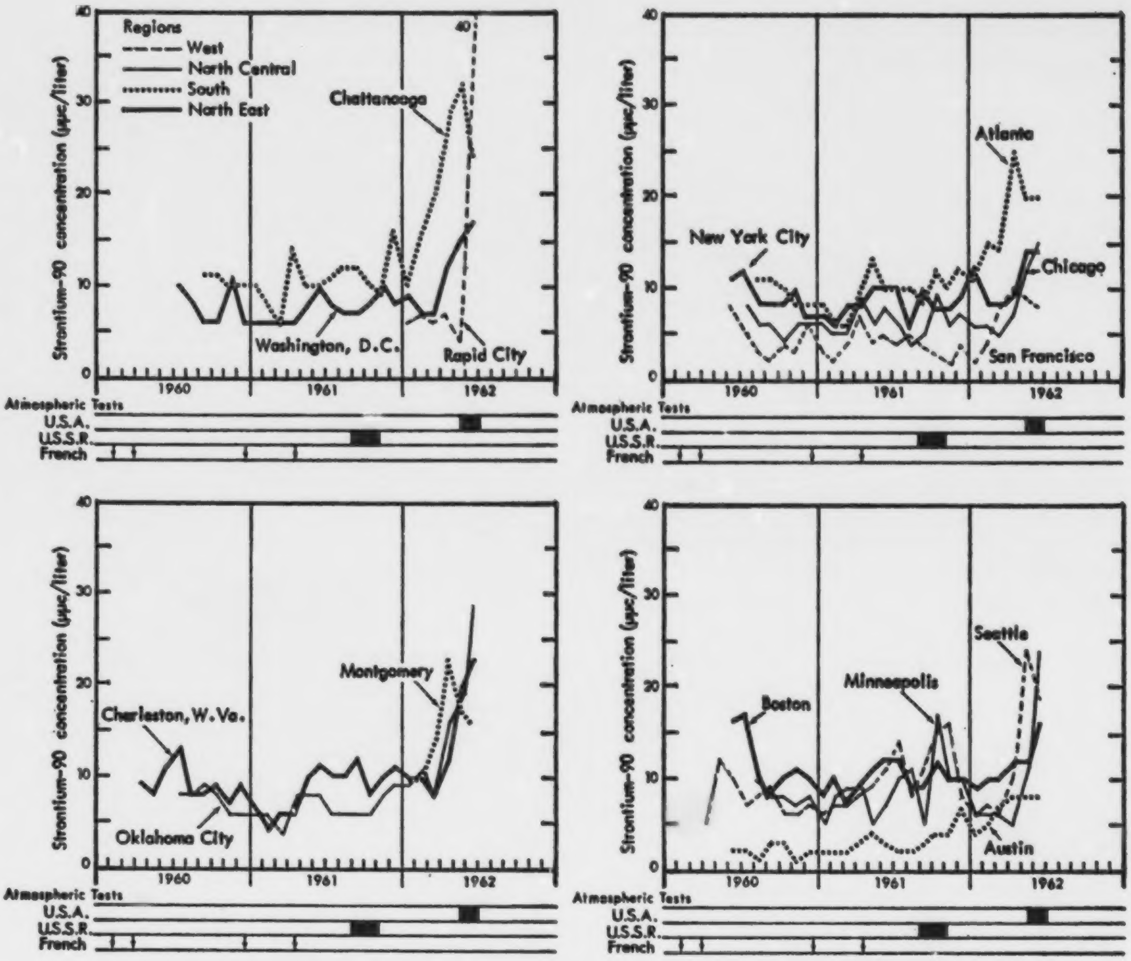

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

regional differences (higher strontium-90 in the East than in the West) are not evident in the selected profiles. The North Central region has shown the greatest change. Strontium-90 concentrations in milk produced in this region are now similar to those prevalent in the South.

Radionuclides in Raw Milk from the Vicinity in the Nevada Test Site

July 1961–June 1962

U.S. Atomic Energy Commission

Shortly after the Operation Plumbob test series in 1957, the Atomic Energy Commission Off-Site Organization at the Nevada Test Site contracted with the Public Health Service's Robert A. Taft Sanitary Engineering Center for analyses of radionuclides in raw milk (Las Vegas milk is pasteurized) produced in the vicinity of the Nevada Test Site. In April 1960, the Southwestern Radiological Health Laboratory of the Public Health Service Division of Radiological Health assumed responsibility for the radionuclide analyses of milk samples obtained in the off-site monitoring program (see sampling locations on figure 1). All milk sample analyses taken in the vicinity of the

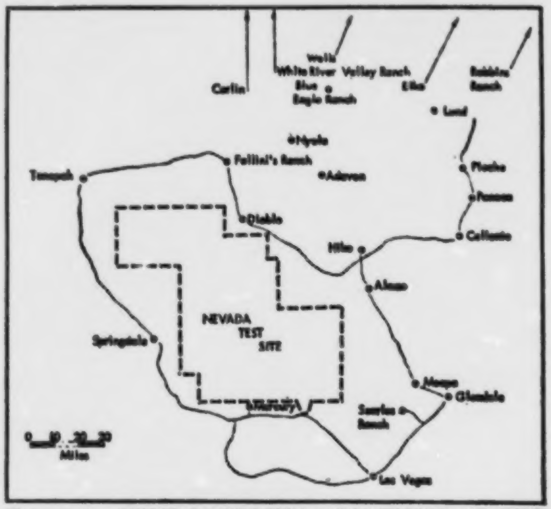

FIGURE 1.—MILK SAMPLING LOCATIONS AT THE NEVADA TEST SITE

TABLE 1.—RADIONUCLIDE CONCENTRATIONS IN MILK SAMPLES FROM THE VICINITY OF NEVADA TEST SITE

[Radioactivity concentrations in μμc/liter]

Collection date	Location	Calcium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140 lanthanum-140
July 20, 1961	Las Vegas	0.94	<5	2	<10	<10	<20
Aug. 21, 1961	Las Vegas	0.86	<5	2	<10	<10	<20
Aug. 15, 1961	Alamo	0.86	<5	2	<10	<10	<20
Sept. 6, 1961	Springdale	[a]—	[a]—	[a]—	<10	<10	570
Oct. 31, 1961	Hiko	1.08	95	4	720	20	60
Oct. 31, 1961	Las Vegas	1.10	15	3	40	<10	<20
Nov. 1, 1961	Glendale	1.06	<5	2	60	<10	<20
Nov. 2, 1961	Caliente	1.20	<5	4	80	<10	20
Nov. 29, 1961	Fallini's Ranch	1.33	40	6	90	50	70
Dec. 1, 1961	Las Vegas	1.02	15	2	40	25	60
Dec. 1, 1961	Diablo	1.16	5	3	30	15	<20
Dec. 13, 1961	Alamo	1.07	10	2	<10	<10	<20
Dec. 13, 1961	Hiko	1.10	<5	2	<10	<10	<20
Dec. 18, 1961	Las Vegas	1.07	<5	4	<10	<10	<20
Dec. 21, 1961	Las Vegas	1.12	5	3	<10	<10	<20
Jan. 3, 1962	Panaca	1.10	<5	2	<10	<10	<20
Feb. 13, 1962	Las Vegas	1.00	<5	2	<10	10	<20
Feb. 22, 1962	Alamo	1.00	<5	2	<10	<10	<20
Feb. 26, 1962	Springdale	1.00	30	3	<10	30	<20
Apr. 4, 1962	Caliente	1.10	5	3	<10	<10	<20
Apr. 18, 1962	Fallini's Ranch	1.18	10	5	<10	10	<20
Apr. 19, 1962	Alamo	1.15	<5	3	<10	<10	<20
Apr. 19, 1962	Panaca	1.14	5	4	<10	10	<20
Apr. 25, 1962	Lund	1.08	<5	4	<10	<10	<20
Apr. 26, 1962	Springdale	1.08	25	4	20	25	<20
May 9, 1962	Lund	1.08	<5	1	<10	<10	<20
May 17, 1962	Hiko	1.14	5	1	<10	<10	<20
June 5, 1962	Searles Ranch	[b]—	[b]—	[b]—	<10	20	<20
June 5, 1962	Las Vegas	[b]—	[b]—	[b]—	<10	30	<20
June 5, 1962	Caliente	[b]—	[b]—	[b]—	<10	25	<20
June 5, 1962	Alamo	[b]—	[b]—	[b]—	<10	35	<20
June 7, 1962	Springdale	[b]—	[b]—	[b]—	<10	50	<20
June 4, 1962	Panaca	[b]—	[b]—	[b]—	<10	<10	<20
June 8, 1962	Fallini's Ranch	[b]—	[b]—	[b]—	<10	70	<20
June 13, 1962	White River Valley Ranch	[b]—	[b]—	[b]—	40	80	<20
June 18, 1962	Blue Eagle Ranch	[b]—	[b]—	[b]—	20	180	<20
June 20, 1962	Adavan	[b]—	[b]—	[b]—	300	75	<20
June 21, 1962	Elko	[b]—	[b]—	[b]—	610	200	<20
June 22, 1962	Robbins Ranch	[b]—	[b]—	[b]—	520	140	<20
June 22, 1962	Carlin	[b]—	[b]—	[b]—	100	120	<20
June 23, 1962	Wells	[b]—	[b]—	[b]—	80	110	<20

[a] Sample not valid.
[b] Not available in time for inclusion.

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Nevada Test Site since July 20, 1961, are reported in table 1. Gross beta concentrations determined by this monitoring program in water supplies in off-site areas of the Nevada Test Site have been published previously in *Radiological Health Data.*

Strontium–90 in Canadian Dried Milk Products

RADIOACTIVE FALLOUT STUDY PROGRAM
First Quarter 1962

Department of National Health and Welfare, Ottawa, Canada

Beginning November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium–90 concentrations were initiated by the Department of National Health and Welfare. Through the cooperation of the Marketing Division of the Canadian Department of Agriculture, four 1-pound samples of dried milk from each station were collected by dairy products inspectors each month for the Radioactive Fallout Study Program. No precise control is maintained over the method of sample collection, since whether or not all samples are collected on the same day or if the sample is truly representative of the milk produced in a given area is not known.

Because of uncertainties introduced by the method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. It is possible, however, to consider all the results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figure 2. It should be emphasized that average concentrations over a considerable period of time are more meaningful from the public health point of view than fluctuating monthly concentrations.

A detailed discussion of the sampling and radiochemical methodology employed may be found in the Department's publication (*1*).

Table 1 presents the results of measurements of strontium–90 in Canadian dried milk powder for the first quarter of 1962, which were taken from the "Quarterly Report of the Radioactive Fallout Monitoring Program," dated July 1961,

TABLE 1.—STRONTIUM-90 IN CANADIAN DRIED MILK POWDER, 1962

[Concentrations in μμc/g Ca]

Station	Type of milk	January	February	March
Calgary	Skim milk	4.8	4.6	5.0
Edmonton	Skim milk	6.6	7.3	5.3
Granby region:				
Lawrenceville	Skim milk	14.0	15.4	14.9
Nicolet	Skim milk	6.0	7.5	8.3
Halifax	Skim milk	7.7	7.0	9.0
La Durantye	Skim milk	11.5	11.2	N.S.
London	Skim milk	3.4	3.3	4.6
Megantic	Skim milk	13.0	10.3	8.8
Moncton	Buttermilk	7.5	6.7	7.7
Ottawa	Skim milk	4.7	5.1	6.1
Saskatoon	Buttermilk	4.7	4.5	6.9
Sussex	Skim milk	8.2	9.4	9.1
Vancouver	Skim milk	7.7	7.0	6.7
Walkerton	Skim milk	4.6	4.4	3.2
Winnipeg region:				
Arborg	Buttermilk	4.8	4.8	4.3
Grunthal	Buttermilk	4.6	4.5	4.0
Average		7.1	7.1	6.9
12-month average (April 1961–March 1962)				0.8

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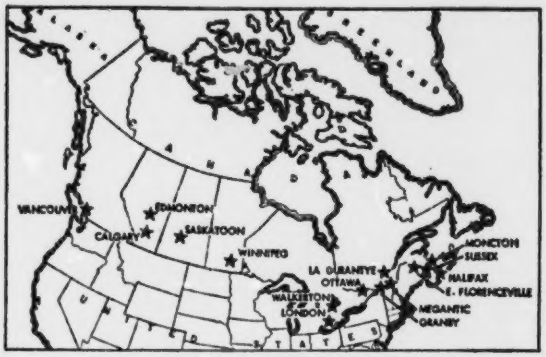

FIGURE 1.—CANADIAN DRIED MILK SAMPLING STATIONS

published by the Radiation Protection Division of the Department of National Health and Welfare.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g Ca to other milk data in units of μμc/liter, it can be assumed that Canadian powdered milk has approximately 1.2 g Ca/liter of liquid milk. Thus, Canadian powdered milk data may be compared to liquid milk by multiplying the former values by 0.8.

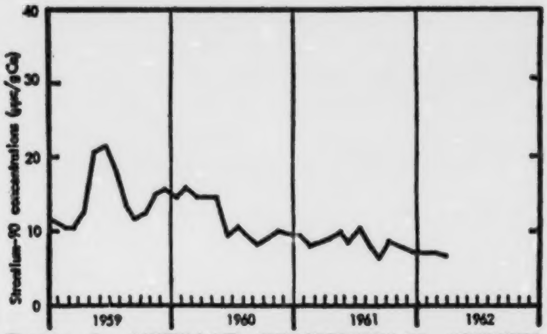

FIGURE 2.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK PRODUCTS

Previous coverage in *Radiological Health Data*:

Period	**Issue**
January 1956–March 1960	***September 1960***
Second quarter 1960	***December 1960***
Third quarter 1960	***April 1961***
Fourth quarter 1960	***August 1961***
First quarter 1961	***December 1961***
Second quarter 1961	***February 1962***
Third quarter 1961	***May 1962***
Fourth quarter 1961	***September 1962***

REFERENCE

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, *CNHW (RP-1)*, (July 1958).

Iodine–131 and Strontium–90 in Milk from the United Kingdom[1, 2]

January 1961–April 1962

Agricultural Research Council Radiobiological Laboratory, England

Since 1958, the Agricultural Research Council Radiobiological Laboratory has performed strontium–90 analyses of raw milk produced in the United Kingdom. For the "country-wide" survey, raw milk samples are obtained every two weeks from over 200 depots selected according to a statistical plan, which handle more than 40 percent of the country's total milk production. The milk samples from the depots are composited to represent each zone as shown in figure 1.

Iodine–131

When it became apparent in September 1961 that the resumption of nuclear weapons testing was likely to lead to an appreciable contamination of milk, arrangements were made to receive milk daily because considerable day to day variations can occur in the iodine–131 concentrations in milk. Thus, during the period when the highest levels occurred (October and November, 1961) samples were obtained daily from up to 23 "regular sampling points" of which at least two were in each of the zones listed in table 1. In addition, country-wide sampling was also carried out once each week to provide fuller information on regional differences. When the levels decreased in early December 1961, the number of regular sampling

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[1] **Agricultural Research Council Radiobiological Laboratory: *Interim Report on Radioactivity in Milk, ARCRL–6*, Her Majesty's Stationery Office, London (December 1961), price 2 s.0d.**

[2] **Agricultural Research Council Radiobiological Laboratory: *Interim Report on Radioactivity in Diet, ARCRL–7*, Her Majesty's Stationery Office, London (May 1962), price 2 s.0d.**

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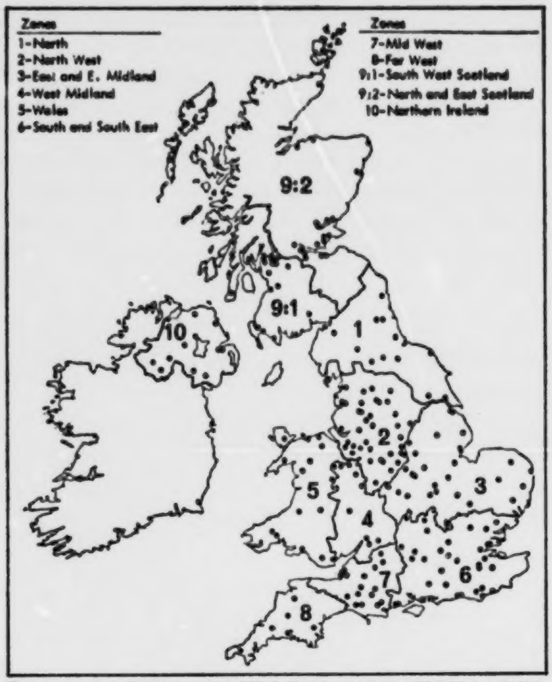

FIGURE 1.—MILK SAMPLING LOCATIONS FOR COUNTRY-WIDE SURVEY

points was reduced to 7 and later to 6, distributed throughout the country. The frequency of the collections from the country-wide survey was reduced to once every 2 weeks. By the end of December the amount of iodine–131 in milk was below the limit of accurate detection in all samples, therefore the number of analyses was further reduced by bulking milk collected from wider areas.

The iodine–131 concentrations were determined by gamma counting after a rapid concentration process. Formalin is added to the milk and the proteins precipitated by the addition of trichloracetic acid; silver halide is subsequently precipitated. The gamma activity of the combined precipitate of protein and silver chloride is then counted using a 4″ by 3″ sodium iodide (thallium activated) crystal; the content of iodine–131 is calculated from the count-rate in the 364 kev photopeak.

The iodine–131 results from the country-wide survey and the regular sampling points have been combined in table 1. Because of the magnitude of day to day variations (see figure 2) the results of the country-wide survey do not by themselves provide a precise estimate of the average level since sampling was commenced. Some samples were collected on days when the results for the regular sampling points show that the content of milk was either appreciably higher or lower than the weekly average. A better estimate of the weekly mean levels throughout the country can be obtained by combining the results for the regular sampling sites with those for the country-wide survey. This was done by applying a correction factor to the country-wide samples consisting of the ratio of the mean value for the regular sampling points on the same day the country-wide sample was taken to the mean value for those points during each week. This calculation was made separately for each zone. For the 10 zones listed in table 1 the mean concentration for the 32 weeks ending April 28, 1962, ranged from 23 to 51 pc/liter, with a country-wide average level of 36 pc/liter.

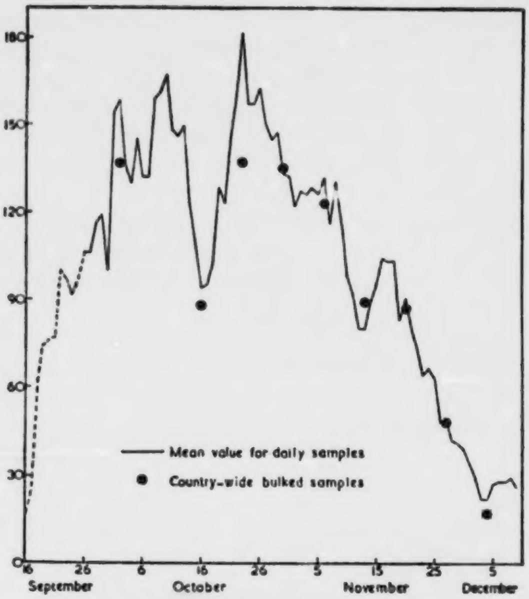

FIGURE 2.—IODINE–131 IN UNITED KINGDOM MILK

Strontium–90

Whereas iodine–131 can be measured in milk within a few hours of the receipt of samples, measurements of strontium–90 take a considerably longer period. Not only is elaborate chemical separation necessary but also the strontium–90 can be adequately determined only by studying the decay of its radioactive daughter, yttrium-90, over a period of several weeks. Therefore, the reporting of strontium-90 analyses lags that for iodine-131 by at least 2 months. January through December 1961 strontium-90 analyses are reported in table 2.

During 1961 the collection of milk for the country-wide survey of strontium-90 contamination was continued on the basis described previously. On account of the marked reduction in the concentrations of strontium-90 in milk during 1960 it was considered justified to reduce the analytical effort given to this work. The milk from 5 zones in England which had previously been assayed separately every 3 months was combined for analysis; after weapons testing was resumed in September 1961, the milk from each zone was again examined separately. In May 1961, the temporary division of Scotland into two zones was abandoned.

TABLE 1.—IODINE-131 CONCENTRATIONS IN MILK THROUGHOUT THE UNITED KINGDOM, 1961–1962

[Average concentrations in pc/liter]

Zone (See figure 1)	September		October					November				December			Apr	Average Sept–Apr
	16–23	24–30	1–7	8–14	15–21	22–28	29–4	5–11	12–18	19–25	26–2	3–9	10–16	17–24	25–28	16–28
1. Northern England	76	97	123	115	87	117	119	88	100	75	27	<15	<15	<15	<15	32
2. Northwest England	57	73	93	131	99	109	115	102	97	73	43	18	<15	<15	<15	32
3. East & East Midlands	52	66	84	78	59	100	81	56	59	66	44	<15	<15	<15	<15	23
4. West Midlands	67	86	108	130	98	111	119	121	118	76	31	31	41	23	<15	36
5. Wales	89	114	145	234	177	201	194	159	155	87	50	24	<15	<15	<15	51
6. South & Southeast England	83	107	136	88	67	84	125	57	84	65	50	24	<15	<15	<15	30
7. Midwestern England	56	72	91	114	86	108	141	124	102	89	50	21	<15	<15	<15	33
8. Farwestern England	52	67	85	187	142	205	175	143	138	79	43	37	37	2[illegible]	<15	44
9. Scotland	139	179	227	208	157	143	104	93	84	30	18	18	<15	<15	<15	44
10. Northern Ireland	132	169	214	152	115	156	163	200	129	77	32	21	34	19	<15	50
Production weighted mean	77	99	125	141	106	127	130	108	103	71	40	20	<15	<15	<15	36

TABLE 2.—STRONTIUM-90 CONCENTRATIONS IN MILK THROUGHOUT THE UNITED KINGDOM, 1961

[Average concentrations in pc/liter]

Zone (See figure 1)	January 1–February 1	February 15–March 15	April 1–May 1	May 15–June 15	July 1–August 1	August 15–September 15	October 1–November 1	November 15–December 15
1. Northern England	[a]—	—	—	—	—	—	[b]6.8	[b]6.8
2. Northwest England	6.7	5.5	6.7	6.4	5.8	5.0	5.2	6.4
3. East & East Midlands	—	—	—	—	—	—	[b]3.7	[b]3.7
4. West Midlands	—	—	—	—	—	—	[b]5.2	[b]5.2
5. Wales	9.4	9.0	10.4	10.01	8.4	8.2	10.4	10.5
6. South & Southeast England	—	—	—	—	—	—	[b]4.2	[b]4.2
7. Midwestern England	6.6	5.1	5.7	6.0	4.6	5.7	5.5	5.6
8. Far Western England	—	—	—	—	—	—	[b]8.8	[b]8.8
9.1 Southwest Scotland	8.4	8.6	9.2	9.2	9.8	8.4	10.0	7.4
9.2 North & East Scotland	7.4	7.4	6.9					
10. Northern Ireland	11.0	10.8	11.4	10.8	9.0	9.6	9.6	11.6
Remainder of England	[b]6.3	[b]6.3	[b]6.4	[b]6.4	[b]6.2	[b]6.2		
Production weighted mean for latest 12 months.		6.93		6.58		6.65		6.82

[a] Dash indicates sample composited with 4 other sections. Analysis is reported as "Remainder of England."

[b] Analysis covers 2 time periods.

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
April 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network, operated in cooperation with State and local agencies, commenced operations in October 1957 (*1*). By the end of April 1962, 108 stations located on major waterways used for public water supply, propagation of fish and wildlife, and recreational, industrial, and agricultural purposes were submitting water samples for analyses of plankton population, organic chemicals, stream flow data, chemical, biological, and physical quality, and radioactivity (*2, 3*). Samples are taken weekly, monthly, or continually, depending on the type of analysis and the degree of water quality.

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment procedures (*4*). Naturally-occuring radioactive substances in the environment are the source of essentially all the alpha activity, while contamination from man-made sources is the major contributor of beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples according to standard procedures (*5, 6*).

For the first two years, alpha determinations were reported generally on composites of more than one weekly sample. As of January 1960, the policy was established that analyses were to be done weekly for the first operating year of each new station. At some stations on the Colorado and Animas Rivers, determinations were done on weekly samples or semimonthly on 2- or 3-week composites. The remainder of the stations were scheduled so that each station made one gross alpha determination per month. Beginning with November 1961, gross alpha determinations have been made on one sample from each station each month, unless there is evidence of alpha activity in excess of background levels. In the latter instance, an alpha determination has been made on a weekly or biweekly basis, depending on the particular station.

For the first two years of the network operations, beta determinations were made on weekly samples. Since January 1959, a portion of each sample from all stations in the network has been composited into a 3-month station sample

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in μμc/liter]

Station	Quarter ending Dec. 31, 1961	April 1962					
	Strontium-90	Beta Activity			Alpha activity		
	Total	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	—	13	8	21	—	—	—
Animas River: Cedar Hill, N. Mex	0.9	71	30	101	17	1	18
Apalachicola River: Chattahoochie, Fla	—	30	24	54	1	0	1
Arkansas River:							
Coolidge, Kansas	1.0	19	62	81	2	15	17
Ponca City, Okla	—	21	54	75	—	—	—
Pendleton Ferry, Ark	—	87	37	124	2	2	4
Big Horn River: Hardin, Mont	—	47	34	81	9	4	13
Big Sioux River: Sioux Falls, So. Dak	1.2	26	74	100	2	2	4
Chattahoochie River: Atlanta, Ga	0.3	15	8	23	0	0	0
Clear Water River: East Lewiston, Idaho	0.3	19	10	29	1	0	1
Colorado River:							
Loma, Colo	—	86	51	137	10	6	16
Boulder City, Nev	1.8	5	18	23	0	7	7
Parker Dam, Calif	—	0	13	13	0	5	5
Yuma, Ariz	—	17	32	49	—	—	—
Columbia River:							
Wenatchee, Wash	0.7	2	9	11	—	—	—
Pasco, Wash	—	72	237	309	—	—	—
McNary Dam, Oreg	—	50	210	260	0	1	1
Connecticut River:							
Northfield, Mass	—	29	21	50	—	—	—
Wilder, Vt	3.7	12	20	32	0	0	0
Cumberland River: Clarksville, Tenn	0.9	—	—	—	—	—	—
Delaware River:							
Philadelphia, Pa	—	23	24	47	—	—	—
Trenton, New Jersey	0.7	10	19	29	0	0	0
Martins Creek, Pa	—	13	16	29	0	0	0
Escambia River: Century, Fla	—	39	27	66	—	—	—
Great Lakes:							
Buffalo, N. Y	0.8	12	16	28	0	0	0
Detroit, Mich	—	3	11	14	0	0	0
Port Huron, Mich	—	7	7	14	—	—	—
Sault Ste. Marie, Mich	—	2	3	5	—	—	—
Gary, Ind	0.1	10	6	16	0	0	0
Duluth, Minn	0.1	2	4	6	0	0	0
Hudson River: Poughkeepsie, N. Y	2.5	—	—	—	—	—	—
Illinois River:							
Grafton, Ill	—	110	57	167	13	0	13
Peoria, Ill	—	28	39	67	—	—	—
Kanawha River: Winfield Dam, W. Va	—	7	15	22	—	—	—
Klamath River: Copeo, Oreg	1.2	18	28	46	—	—	—
Little Miami River: Cincinnati, Ohio	0.6	7	37	44	1	0	1
Mississippi River:							
St. Paul, Minn	—	40	66	106	0	1	1
Dubuque, Iowa	—	44	22	66	2	0	2
Burlington, Iowa	—	58	37	95	9	0	9
E. St. Louis, Ill	—	48	42	90	3	0	3
Cape Giraudeau, Mo	—	66	40	106	12	2	14
Delta, La	—	69	38	107	3	1	4
New Orleans, La	—	78	26	104	4	1	5
Vicksburg, Miss	—	56	31	87	2	<1	2
Missouri River:							
Williston, N. Dak	—	38	19	57	—	—	—
Bismarck, N. Dak	—	14	25	39	1	4	5
Yankton, S. Dak	2.5	64	82	146	—	—	—
Omaha, Nebr	—	38	63	101	—	—	—
St. Joseph, Mo	—	254	49	303	—	—	—
Kansas City, Kans	—	277	57	334	—	—	—
Missouri City, Mo	—	164	39	203	19	2	21
St. Louis, Mo	2.1	124	48	172	—	—	—
Monongahela River: Pittsburgh, Pa	—	4	13	17	<1	<1	1
North Platte River: Henry, Nebr	1.3	17	50	67	1	31	32
Ohio River:							
East Liverppol, Ohio	—	11	25	36	2	0	2
Huntington, W. Va	—	32	19	51	—	—	—
Cincinnati, Ohio	—	55	17	72	3	0	3
Louisville, Ky	—	46	16	62	4	1	5
Evansville, Ind	—	46	15	61	—	—	—
Cairo, Ill	—	158	14	172	14	0	14
Ouachita River: Bastrop, La	0.7	40	52	92	0	<1	<1
Platte River: Plattsmouth, Nebr	—	83	54	137	16	6	22
Potomac River:							
Williamsport, Md	0.9	12	14	26	0	0	0
Great Falls, Md	—	18	16	34	—	—	—
Rainy River:							
Baudette, Minn	—	2	14	16	1	0	1
International Fls, Minn	—	2	12	14	0	0	0
Red River, South:							
Alexandria, La	—	124	46	170	6	0	6
Denison, Tex	—	29	27	56	1	1	2
Rio Grande River:							
Alamosa, Colo	—	29	26	55	1	2	3
El Paso, Tex	—	39	22	61	—	—	—
Laredo, Tex	—	13	45	58	1	3	4
Brownsville, Tex	—	3	27	30	—	—	—

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in μμc/liter]

Station	Quarter ending Dec. 31, 1961	April 1962					
	Strontium-90	Beta Activity			Alpha activity		
	Total	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Roanoke River: John H. Kerr Resr. & Dam, Va.	—	36	20	56	<1	0	<1
Sabine River: Ruliff, Tex.	—	23	31	54	—	—	—
San Juan River: Shiprock, N. Mex.	—	123	26	149	14	2	16
St. Lawrence River: Massena, N. Y.	1.6	16	20	36	1	0	1
Schuylkill River: Philadelphia, Penn.	—	9	15	24	—	—	—
Savannah River: Port Wentworth, Ga.	—	16	27	43	0	0	0
Shenandoah River: Berryville, Va.	0.2	30	13	43	1	0	1
Snake River:							
Wawawai, Wash.	—	12	14	26	—	—	—
Payette, Idaho.	—	30	26	56	1	2	3
South Platte River: Julesburg, Colo.	—	40	46	86	3	19	22
Susquehanna River:							
Sayre, Pa.	—	30	15	45	—	—	—
Conowingo, Md.	—	26	16	42	3	0	3
Tennessee River:							
Lenoir City, Tenn.	—	13	14	27	0	0	0
Chattanooga, Tenn.	0.5	24	58	82	1	0	1
Pickwick Landing, Tenn.	—	31	38	69	0	0	0
Tombigbee River: Columbus, Miss.	0.2	—	—	—	—	—	—
Truckee River: Farad, Calif.	—	28	15	43	1	0	1
Verdigris River: Nowata, Okla.	—	20	40	60	0	2	2
Yakima River: Richland, Wash.	—	16	11	27	<1	<1	1
Yellowstone River: Sidney, Mont.	—	46	33	79	—	—	—

for measurement of strontium-90 (*7*). Beginning January 1960, analyses were performed weekly for the first operating year of each new station. Weekly analyses were to be continued indefinitely for all stations which may be affected by waste discharges from nuclear installations. Where stations have been operated for more than 1 year, semimonthly determinations on composites of 2 or 3 weekly samples were performed when beta activity was found to be above background. Monthly determinations on composites of all samples received from a station during the month were conducted on samples from streams where beta activity was at background levels. Since September 1961, gross beta determinations have been made on all samples collected.

The data reported in table 1 represent the average of all data reported for the periods indicated. The reported strontium-90 data are the results of determinations on 3-month composite samples for the quarter ending in the month shown.

REFERENCES

(*1*) Public Health Service: National Water Quality Control Network, *Fallout From Nuclear Weapons Tests*, *1*:167–9, Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 1959).

(*2*) Division of Water Supply and Pollution Control, Public Health Service: "*National Water Quality Network Annual Compilation of Data*," PHS publication No. 663, 1960 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

(*3*) Setter, L. R., and S. L. Baker: Radioactivity of Surface Waters in the United States, *Radiological Health Data*, *1*:20–31 (October 1960).

(*4*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association*, *53*:704 (June 1961).

(*5*) Setter, L. R., J. E. Regnier, and E. A. Diephaus: Radioactivity of Surface Waters in the United States, *Journal of the American Water Works Association*, *51*:1377 (November 1959).

(*6*) Robert A. Taft Sanitary Engineering Center, Public Health Service: Radionuclide Analysis of Environmental Samples, Technical Report, R59-6 (1959).

(*7*) Straub, C. P., L. R. Setter, A. Goldin, and P. F. Hallbach: Strontium-90 in Surface Waters in the U.S., *Journal of the American Water Works Association*, *52*:756 (June 1960).

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Radionuclide Analyses of Coast Guard Water Supplies
October 1961–April 1962

U.S. Coast Guard and Division of Radiological Health, Public Health Service

From 1957 through 1960, monthly samples of several U.S. Coast Guard light station rain water cistern supplies were routinely analyzed for beta activity by the Robert A. Taft Sanitary Engineering Center (*1*, *2*). Due to the resultant low radioactivity concentrations two years after the 1958 cessation of nuclear weapons testing, this sampling procedure was terminated.

Since October 1961, drinking water samples have been obtained from Coast Guard Loran Stations in Alaska. In most cases, these samples are collected from small artificial impoundments or lakes. The sampling sites are shown in figure 1.

The radionuclide analyses reported in table 1 were performed by the Southwestern Radiological Health Laboratory at Las Vegas, Nevada.

REFERENCES

(*1*) Straub, C. P.: Statement on New Data on Uptake in Milk, Food, and Human Bone, *Joint Committee on Atomic Energy Hearings on Fallout From Nuclear Weapons Tests*, *2*:990 (May 1959).

(*2*) U.S. Coast Guard: Analyses of Cistern Water, *Radiological Health Data*, June 1960, July 1960, and August 1961.

TABLE 1.—RADIONUCLIDES IN WATER SAMPLES FROM U. S. COAST GUARD LORAN STATIONS, OCTOBER 1961–APRIL 1962

[Concentrations in $\mu\mu c$/liter]

Alaskan location	Collection date	Gross alpha	Gross beta	Sr^{90}	Ra^{226}	I^{131}	Ba^{140}	Cs^{137}	Zr^{95}
Adak	Dec. 14, 1961	5.8	12	1.5	[a] ND	ND	ND	ND	ND
	Jan. 2, 1962	12.2	40	0.9	0.1	40	40	ND	20
	Feb. 13, 1962	0.7	11	0.3	0.2	ND	20	ND	ND
	Mar. 20, 1962	ND	28	[b]—	—	ND	15	ND	ND
Attu	Dec. 22, 1961	ND	51	0.4	ND	30	30	10	30
	Jan. 3, 1962	3.4	85	1.2	0.8	ND	105	ND	45
	Feb. 13, 1962	ND	80	1.7	ND	ND	45	ND	20
	Mar. 26, 1962	0.7	40	1.7	0.1	ND	25	5	ND
Biorka	Dec. 14, 1961	1.5	137	3.4	0.3	ND	80	ND	50
	Jan. 11, 1962	0.6	134	0.9	ND	ND	135	ND	85
	Feb. 13, 1962	ND	173	0.9	0.4	ND	80	ND	70
	Mar. 23, 1962	2.1	156	0.9	ND	ND	110	ND	120
	Apr. 22, 1962	ND	122	0.6	—	ND	ND	ND	85
Cape Sarichef	Dec. 22, 1961	16.8	7	0.4	ND	ND	ND	ND	ND
	Jan. 3, 1962	1.0	7	0.4	ND	45	10	5	ND
	Feb. 14, 1962	1.1	13	ND	—	ND	ND	ND	ND
	Mar. 19, 1962	ND	61	—	—	ND	ND	ND	ND
	Apr. 20, 1962	ND	11	0.7	ND	ND	ND	ND	ND
Port Clarence	Oct. 1961	1.1	48	0.8	ND	ND	ND	ND	ND
	Nov. 1961	ND	12	1.1	0.3	ND	ND	ND	ND
	Mar. 19, 1962	ND	18	—	0.4	ND	ND	ND	ND
	Apr. 23, 1962	1.1	13	0.3	—	ND	ND	ND	ND
Sitkinak	Dec. 21, 1961	15.6	12	0.5	0.4	ND	ND	ND	ND
	Jan. 6, 1962	4.4	76	0.3	0.6	ND	60	ND	30
	Feb. 14, 1962	ND	120	1.7	ND	ND	55	ND	65
	Mar. 20, 1962	ND	53	2.0	0.3	ND	10	ND	30
	Apr. 26, 1962	ND	39	0.7	—	ND	ND	ND	15
Spruce Cape	Dec. 13, 1961	3.3	25	2.5	0.2	ND	ND	ND	ND
	Jan. 4, 1962	1.1	70	0.8	0.4	40	45	ND	ND
	Feb. 13, 1962	2.4	465	2.7	ND	ND	185	30	230
	Mar. 20, 1962	1.0	109	2.8	0.3	ND	30	ND	20
	Apr. 13, 1962	1.0	80	0.6	—	ND	15	ND	40
	Apr. 16, 1962	ND	608	6.2	—	ND	ND	ND	605

[a] ND indicates radionuclide not detectable.
[b] Dash indicates result not reported.

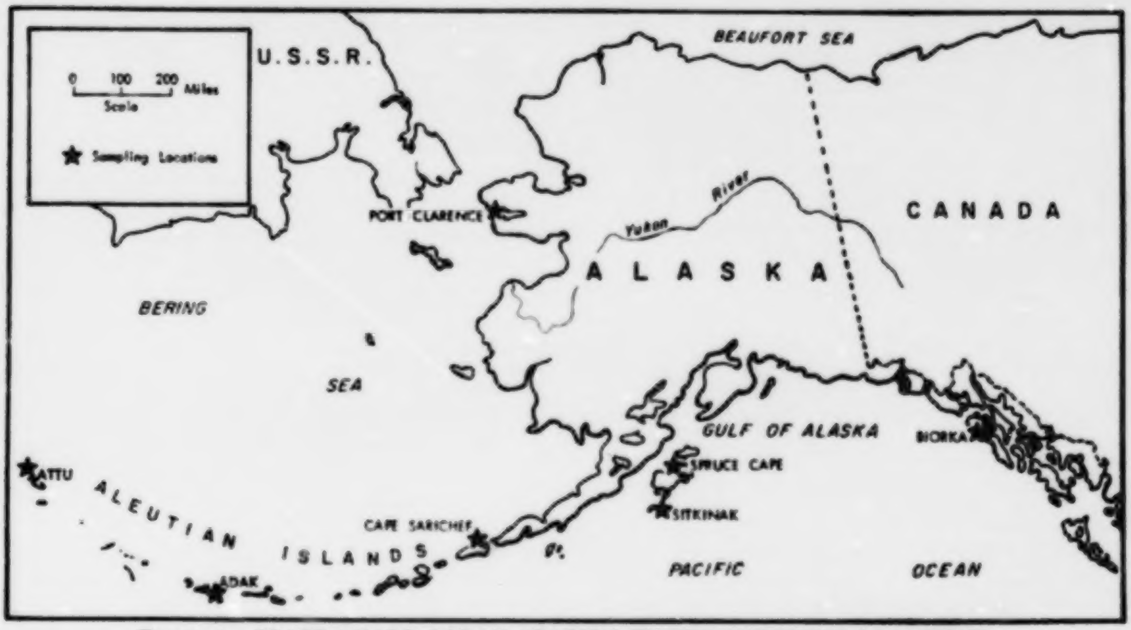
U.S.S.R.
BEAUFORT SEA
0 100 200 Miles
Scale
Sampling Locations
PORT CLARENCE
Yukon River
CANADA
ALASKA
BERING SEA
GULF OF ALASKA
BIORKA
SPRUCE CAPE
SITKINAK
ATTU
ALEUTIAN ISLANDS
CAPE SARICHEF
ADAK
PACIFIC OCEAN

FIGURE 1.—COAST GUARD LORAN STATION WATER SAMPLING LOCATIONS

Radioactivity in Drinking Water

DRINKING WATER ANALYSIS PROGRAM 1961

Division of Environmental Engineering and Food Protection, Public Health Service

The Water Section Activity of the Interstate Carrier Branch, Division of Environmental Engineering and Food Protection, PHS, has gathered extensive data on the radioactivity content of water supplies used on interstate carriers such as trains, airplanes, ships, and other conveyances operating in interstate commerce. This work has several objectives, among which are:

1. to determine radioactivity content of interstate carrier water supplies for comparison with the revised Public Health Service Drinking Water Standards (*1, 2*);
2. to establish the background level as the basis with which to compare future results from the supplies sampled; and
3. to obtain data for study in connection with the occurrence of certain chronic diseases.

Beginning in November 1960, the project is a continuing one under which it is planned ultimately to sample the 850 U.S. water supplies used by interstate carriers. In many instances, there are several sources for a municipality and each is sampled. When the present water supply sampling for the second group of cities is completed, another group of about 100 cities will be chosen.

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Each sample is a 4-liter composite of three 270-ml aliquots a day obtained during a two-week period. The gross alpha, gross beta, and strontium-90 analyses are performed at the Southeastern, Northeastern, and Southwestern Radiological Health Laboratories, operated by the Division of Radiological Health. Table 1 presents partial data from the second sampling.

Previous coverage in *Radiological Health Data*:

Period	Issue
1961	*May 1962*
1960 and 1961	*August 1962*

REFERENCES

(*1*) Public Health Service: Drinking Water Standards, 1962 Revision, PHS Regulations, (March 6, 1962).

(*2*) Drinking Water Standards for Radioactivity, *Radiological Health Data, 3*:156–7 (May 1962).

TABLE 1.—RADIOACTIVITY IN DRINKING WATERS

[Concentrations in μμc/liter]

Station		Population served	Date sampled	Strontium-90	Alpha Activity			Beta activity		
City	State			Total solids	Suspended	Dissolved	Total	Suspended	Dissolved	Total*
Mobile	Ala.	202,779	11/16-12/2/61					<3.0	6.3	<9.3
Montgomery		134,393								
Court St. Pump Sta.			5/30-6/13/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Day St. Pump Sta.			5/31-6/15/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
TVA Widows Creek			6/7-6/22/61	1.1				<3.0	37.0	40.0
Tampa	Fla.	274,970	4/25-5/9/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Atlanta	Ga.	487,455								
Chattahoochee Plant			8/15-9/1/61					<3.0	<3.0	<6.0
Hemphill Plant			8/15-8/30/61					<3.0	<3.0	<6.0
Columbus		116,779	11/14-11/28/61					<3.0	4.5	<7.5
Elkhart	Ind.	40,274	6/16-6/30/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Evansville		141,543	6/15-6/30/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Muncie		68,603	1/18-2/1/61	0.2	<0.5	<0.5	<1.0	<2.6	<2.6	<5.2
Washington		10,846	6/13-6/21/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Ashland	Ky.	31,283	1/26-2/9/61	0.1		<0.5			<2.6	
Paducah		34,479	11/2-11/17/60					<1.0	6.8	7.8
Louisville		390,639	6/14-6/28/61		<0.5	<0.5	<1.0	<3.0	3.2	<6.2
Portland	Maine	72,566	3/20-4/3/61		<0.5	<0.5	<1.0	<3.0	3.9	<6.9
Ann Arbor	Mich.	67,340	4/20-5/6/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Greenville	Miss.	41,502	1/12-1/27/61	0.5	<0.5	<0.5	<1.0	<2.6	<2.6	<5.2
Jackson		144,422	6/1-6/15/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Vicksburg		29,130	2/15-3/2/61	0.6		<0.5			4.3	
Charlotte	N. C.	201,564								
Hoskins Filter Plant			3/30-4/14/61	1.0	<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Vest Station			3/30-4/14/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Raleigh		93,931	4/10-4/24/61	1.0	<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Winston-Salem		111,135	2/14-3/1/61	0.2		<0.5			<2.6	
Akron	Ohio	290,351	8/18-9/1/61					3.6	<3.0	<6.6
Lancaster	Pa.	61,055								
Conestoga Plant			7/13-7/27/61					<3.0	<3.3	<6.3
Susquehanna Plant			8/29-9/12/61					<3.0	<3.0	<6.0
Charleston	S. C.	65,925	1/10-1/25/61					<3.0	<3.0	<6.0
North Augusta		10,348	9/4-9/17/61					<3.0	<3.0	<6.0
Chattanooga	Tenn.	130,009	7/12-7/28/61	3.2				<3.0	45.0	48.0
Clarksville		22,021	7/6-7/24/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Knoxville		111,827	8/18-9/1/61					<3.0	<3.0	<6.0
Huntington	W. Va.	83,627	12/9-12/27/61	0.7				<1.0	<2.2	<3.2

* Where "less than" values comprise not more than 10 percent of a total, the "less than" sign is not shown with the total.

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SECTION V.—OTHER DATA

Whole Body Counting

Whole body counters are being applied where the detection of low levels of radioactivity in the human body is important, as, for example in the evalution of hazards to radiation workers and the general population. These instruments are also used in human physiological and pathological investigations as well as in studies related to counter design for special purposes. Discussion and presentation of whole body counting results in previous issues of *RHD* have been limited to medical research programs employing thallium-activated sodium iodide crystals or liquid scintillation solutions. As other whole body counting data become available, they will be published.

CESIUM-137 IN MAN
March 1962 through May 1962

U.S. Army Medical Research Unit, Landstuhl, Germany

In 1955, cesium-137 was first detected in man by the Argonne National Laboratory. It emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium-137 levels are usually expressed in micromicrocuries per gram of potassium. The whole body counting facility at the Medical Research Unit, Landstuhl, Germany, in its program for measuring the cesium-137 levels in man, utilizes a liquid scintillation counter (*1*).

TABLE 1.—ASSAYS PERFORMED AT U.S. ARMY MEDICAL RESEARCH UNIT, LANDSTUHL, GERMANY

Date	Number of subjects	Residence	Cesium-137 $\mu\mu c$/gK (average)	Percent MPBB*
March 1962	250	West Germany	27	0.13
April 1962	168	West Germany	28	0.13
May 1962	418	West Germany	34	0.16

* Percent maximum permissible body burden was calculated using 3 μc of cesium-137 as the general population maximum permissible whole body burden and 140 grams of potassium in the body of the "standard man." (See pp. 187 and 192 of Radiological Health Handbook, Office of Technical Services, U. S. Department of Commerce (1960), price $3.75.)

Previous coverage in *Radiological Health Data*:

Period	Issue
1958 and 1959	*October 1960*
1959 and 1960	*January 1961*
1958, 1959, and 1960	*April 1961*
First quarter 1961	*July 1961*
Second quarter 1961	*October 1961*
Third quarter 1961	*January 1962*
First quarter 1962	*August 1962*

REFERENCE

(*1*) *Radiological Health Data 2*:192–4 (April 1961).

External Gamma Activity

RADIATION SURVEILLANCE NETWORK
July 1962

Division of Radiological Health, Public Health Service

Daily measurements of external gamma radiation are made at stations of the Radiation Surveillance Network to assure detection of any substantial deviations from normal background levels. Portable Geiger-Mueller survey instruments are used to obtain measurements at three feet above the ground surface. July 1962 data reported in table 1 are characteristic of individual station observations which in recent years have defined the range of background values.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, JULY 1962

Station location		Average (mr/hr)	Station location		Average (mr/hr)
City	State		City	State	
Adak	Alaska	0.01	Minneapolis	Minn.	0.01
Anchorage	Alaska	0.01	Jackson	Miss.	0.01
Attu	Alaska	0.01	Pascagoula	Miss.	0.01
Fairbanks	Alaska	0.01	Jefferson City	Miss.	0.01
Juneau	Alaska	0.01	Helena	Mont.	0.03
Kodiak	Alaska	0.01	Lincoln	Nebr.	0.08
Nome	Alaska	0.01	Las Vegas	Nev.	0.01
Point Barrow	Alaska	0.01	Concord	N. H.	—
St. Paul Island	Alaska	0.01	Trenton	N. J.	0.02
Phoenix	Ariz.	0.01	Santa Fe	N. Mex.	0.04
Little Rock	Ark.	0.01	Albany	N. Y.	0.02
Berkeley	Calif.	0.01	Buffalo	N. Y.	0.01
Los Angeles	Calif.	0.02	New York	N. Y.	—
Denver	Colo.	0.02	Gastonia	N. C.	0.02
Hartford	Conn.	0.01	Bismarck	N. D.	0.01
Dover	Del.	0.01	Columbus	Ohio	0.01
Washington	D. C.	0.04	Painesville	Ohio	0.01
Jacksonville	Fla.	0.01	Oklahoma City	Okla.	0.02
Miami	Fla.	0.01	Ponca City	Okla.	0.02
Atlanta	Ga.	[a]—	Portland	Ore.	0.02
Agana	Guam	0.01	Harrisburg	Pa.	0.02
Honolulu	Hawaii	0.01	San Juan	P. R.	0.01
Boise	Idaho	0.01	Providence	R. I.	0.02
Springfield	Ill.	0.01	Columbia	S. C.	0.02
Indianapolis	Ind.	0.01	Pierre	S. D.	0.02
Iowa City	Iowa	0.01	Nashville	Tenn.	0.01
Topeka	Kans.	0.03	Austin	Tex.	0.01
Frankfort	Ky.	0.01	El Paso	Tex.	0.02
New Orleans	La.	0.02	Salt Lake City	Utah	0.02
Augusta	Maine	0.02	Barre	Vt.	0.02
Presque Isle	Maine	0.02	Richmond	Va.	0.01
Baltimore	Md.	0.02	Seattle	Wash.	0.02
Rockville	Md.	—	Charleston	W. Va.	—
Lawrence	Mass.	0.02	Madison	Wis.	0.01
Winchester	Mass.	0.01	Cheyenne	Wyo.	0.02
Lansing	Mich.	0.02			

[a] Dash indicates no data received.

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 21 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Hanford Atomic Products Operation, Lawrence Radiation Laboratory, and Los Alamos Scientific Laboratory.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in National Bureau of Standards "Handbook 69." The MPC values applicable to the following reports are given in table 1.

To avoid any possible misunderstandings in the use of the term "Maximum Permissible Concentrations," the Federal Radiation Council (FRC) has recommended the term "Radioactivity Concentration Guide" (RCG) for the use of Federal Agencies. Although FRC has not published a table of RCG values, several AEC installations, have adopted FRC nomenclature and use the NCRP published values or have derived their own RCG values on the basis of Radiation Protection Guides (RPG's) such as 500 mrem/year total body exposure. For a more detailed description of the meaning and use of the RCG, the reader is referred to FRC Report No. 2.[*] The RPG's in terms of total intake in μμc/day averaged over a 1-year period which are recommended in FRC Report No. 2 are as follows: the upper limits of Range II for radium-226, iodine-131, strontium-90 and strontium-89 are 20, 100, 200, and 2000 respectively.

In the following reports, the use of nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when con-

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[*] Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., price 20 cents.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radionuclide or mixture of unknown nuclides	Environmental MPC's	
		Water (μμc/liter)	Air (μμc/m³)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, Pu^{241} are not present[a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present[a]	—	100
8	Arsenic-76	20,000	3,000
9	Copper-64	200,000	40,000
10	Chromium-51	2,000,000	80,000
11	Iodine-131 (FRC Guide: 100 μμc/day)	2,000	300
12	Manganese-56	100,000	20,000
13	Neptunium-239	100,000	30,000
14	Phosphorus-32	20,000	2,000
15	Plutonium-239	5,000	0.06
16	Silicon-31	200,000	30,000
17	Sodium-24	30,000	5,000
18	Strontium-90	100	10
19	Uranium-natural	20,000	2

[a] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to recent AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

centrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justfy a less restrictive value. References to table 1 will be made to designate the appropriate MPC's reported by the laboratories.

HANFORD ATOMIC PRODUCTS OPERATION

Third and Fourth Quarters 1961

General Electric Company
Richland, Washington

The Hanford Atomic Products Operation (HAPO) is located in a semi-arid region of southeastern Washington. The project is a five-hundred square mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities, and research and development laboratories.

Various radioactive wastes which result from plant operations are disposed through controlled releases to the atmosphere, ground, and the waters of the Columbia River. A primary responsibility of plant personnel is to monitor and safeguard against any effects these wastes may have on the 80,000 residents of Richland, Pasco, Kennewick, and other communities in the vicinity of the project.

The monitoring program includes surveillance of the atmosphere, vegetation, fish and wildlife, milk and agricultural produce, and the waters of the Columbia River and Pacific Ocean. Further measurements are made of external radiation and possible ground contamination from burial pits.

Atmosphere

Gaseous wastes are released to the atmosphere through 200-foot stacks after removal of most radioactive material originally present.

Hanford project maintains air sampling stations at Benton City, Kennewick, Pasco, Richland, Seattle, Spokane, Walla Walla, and Yakima, Washington; Meacham and Klamath Falls, Oregon; Boise and Lewiston, Idaho; and Great Falls, Montana. Sample filters are changed weekly and sent to Hanford for analyses. Third and fourth quarter 1961 summaries of beta concentration in these filters are presented in table 2.

TABLE 2.—AVERAGE AIR-BORNE BETA ACTIVITY IN SELECTED PACIFIC N. W. LOCATIONS, HAPO

[Average concentrations in $\mu\mu c/m^3$]

Sampling location	Third Quarter 1961		Fourth Quarter 1961	
	No. of samples	Beta	No. of samples	Beta
Richland, Wash.	13	0.56	14	6.10
Boise, Idaho	11	0.44	13	8.70
Hanford project	13	0.54	14	4.70
Seattle, Wash.	13	0.18	14	3.38
Meacham, Ore.	13	0.15	13	4.14

Releases of iodine–131 are of particular interest and routine measurements are made at several locations around the plant area. Total stack releases averaged 0.78 and 0.55 curies per day for the third and fourth quarters, respectively, and the concentrations in the local environmental air are shown in table 3.

TABLE 3.—IODINE-131 IN AIR AT PERIMETER COMMUNITIES, HAPO

[Average concentration in $\mu\mu c/m^3$]

Station	Third Quarter 1961		Fourth Quarter 1961	
	No. of samples	I^{131}	No. of samples	I^{131}
Richland	13	0.011	13	0.054
North Richland	13	0.014	13	0.118
Benton City	12	0.022	12	0.026
Pasco	13	0.015	11	0.107

Water

Hanford's eight production reactors are cooled by treated water pumped from the Columbia River. After the water passes through the reactors, it is returned to the river. Some radioactivity results from neutron activation of impurities remaining in the treated water and is discharged in the effluent. The major part (90 percent) of this radioactive material consists of Mn^{56}, Cu^{64}, Na^{24}, Cr^{51}, Np^{239}, As^{76}, and Si^{31}. Although the presence of Zn^{65}, P^{32}, and certain other radionuclides are of interest, they are found only in minor quantities. River water samples are taken at Hanford Ferry, Pasco, and Vancouver to be analyzed for several radionuclides. Selected results are presented in table 4.

TABLE 4.—SELECTED RADIONUCLIDES IN COLUMBIA RIVER WATER, HAPO

[Average concentration in μμc/liter]

Sampling location	Third Quarter 1961			Fourth Quarter 1961		
	Na^{24}	P^{32}	Zn^{65}	Na^{24}	P^{32}	Zn^{65}
Hanford Ferry	9150	184	350	11,600	328	500
Pasco	1750	99	158	2,120	234	238
Vancouver	[a]—	22	87	—	42	<24

[a] Dash indicates no analysis.

Fish and Wildlife

Fish in the Columbia River accumulate some of the radionuclides present in water and whitefish in particular concentrate phosphorus–32 which is a major bone seeker. The average concentration of phosphorus–32 in the flesh of whitefish caught near the plant was 800 μμc/g.

Migratory waterfowl, which may have utilized the Hanford section of the Columbia River were obtained from hunters in Washington, Oregon, Idaho, and California. Analyses of 1500 of these specimens showed that only one out of thirteen contained concentrations of phosphorus–32 greater than the detection level of 50 μμc/g and the maximum concentration found was 2,600 μμc P^{32}/g.

In order to determine the kinds, number, and disposition of local fish and waterfowl harvested, a creel survey was initiated in 1961. This survey is being carried out by contract with the Washington Department of Game.

An estimated 10 pounds of whitefish per person per year for roughly 2,000 people in the Pasco-Kennewick-Richland area was used in the evaluation of population dose from fish and waterfowl: (*Editor's note:* Refer to *Radiological Health Data,* February 1962, pp. 63-4 for a graphic presentation of the estimated population dose in the Hanford vicinity for 1960. The 1961 estimates are similar.)

Milk and Agricultural Produce

There is no farming within about a 20-mile radius of the chemical separations facilities (the major local source of air-borne radionuclides), but the Ringold farms and Riverview District of Pasco, which are respectively about 15 and 30 miles downstream from the reactors, take water from the Columbia River. Some radionuclides are traced though the irrigation process into milk and produce.

Analyses of local milk for strontium–90, strontium–89, and cesium–137 indicated average concentrations which ranked among the lowest in the nation. These radionuclides result predominantly from world-wide fallout. However, phosphorus–32 and zinc–65 in milk originate from the irrigation water and the 1961 average concentrations of phosphorus–32 in milk from dairy farms in the Ringold and Pasco areas were 725 and 622 μμc/liter respectively. The zinc–65 average concentration was 725 μμc/liter at Ringold and 518 μμc/liter at Pasco.

Assays of local milk for iodine–131 during the third quarter revealed little contamination and the average was less than 60 μμc/liter. Fallout after the resumption of nuclear testing caused a brief rise in iodine–131 and on November 2, 1961 the maximum local concentration reached 1,500 μμc/liter. However, the rapid decay rates of iodine–131 and the use of dry winter feeds allowed the concentration in milk to drop to about 2 μμc/liter by late December.

Measurements were made on samples of pasture grass to estimate the iodine–131 intake from leafy vegetables. Prior to the arrival of world-wide fallout, the average concentration was 0.2 μμc/g; after the arrival of fallout, external sources of nuclides introduced a large source of error which interfered with estimations of exposure from plant emissions.

External Radiation

Ionization chambers located above ground and in the Columbia River were used to estimate the combined exposure from external sources in the Hanford area. Aboveground measurements indicated an annual exposure in 1961 of about 130 mr. Virtually all of this radiation is attributable to natural background.

The presence of gamma emitters, especially Na^{24}, in reactor effluent causes a higher exposure rate in the river. The average dose in the water near Richland was about 2.5 mr/day and near Kennewick about 0.9 mr/day. This would mean that a person swimming or boating in the river for 240 hours per year would receive about 25 mr of exposure.

Ground Releases

Solid wastes are packaged and buried in trenches; "high level" liquid wastes which normally contain activity of 10^{11} μμc/liter or more are neutralized and stored in concrete tanks lined with steel; "intermediate level wastes" containing activity between 5×10^4 and 10^{11} μμc/liter are sent to underground cribs from which waste can percolate into the soil; and "low level wastes" containing less than 5×10^4 μμc/liter are sent to depressions in the ground where they form surface ponds.

To monitor the extent to which radionuclides reach the ground water, wells have been drilled in crib and tank storage areas. Figure 1 shows the probable extent and concentration of radioactive materials in ground water.

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first and second quarters 1960	*May 1961*
Third and fourth quarters 1960 and first and second quarters 1961	*February 1962*

LAWRENCE RADIATION LABORATORY
Third and Fourth Quarters 1961

University of California
Berkeley, California
Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located adjacent to the campus of the University of California. The technical facilities include a 6.3 Bev proton accelerator, a 700 Mev cyclotron, a linear accelerator of 10 Mev per nucleon, and various chemistry and physics laboratories.

The environmental sampling program includes atmospheric samples of stack releases, local area air, perimeter air, and rain or dry deposition; and water samples of building wastes, tap water, surface water, and off-site creeks. Analyses are made for alpha and beta concentrations.

Approximately 30 to 40 stacks, mostly laboratory hood exhausts, were sampled during the 3rd and 4th quarters. The normal sampling period was one week. Filters were then counted for alpha and beta activity.

Outdoor air samples were taken daily or weekly at three locations within the laboratory area and at four locations along the University of California property line. One additional sampling site is now located in downtown Berkeley to provide background information on contamination from weapons testing.

A summary of 3rd and 4th quarter air monitoring data is presented in table 5.

TABLE 5.—ATMOSPHERIC MONITORING, BERKELEY SITE

[Average concentration in μμc/m³]

Sampling locations	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Stacks	498	0.017	0.60	404	0.031	5.30
Local air	70	0.002	0.82	85	<0.002	8.43
Perimeter air	[a]16	<0.002	2.40	47	<0.002	8.29
Reference sample[b]	—	—	—	32	0.003	6.35

[a] Predominantly September samples.
[b] Downtown Berkeley location began operation November 1961.

Rain and/or dry deposition was sampled at irregular intervals at one location during the 3rd quarter, but beginning with the 4th quarter the sampling program was increased to provide weekly data at 7 sites. Fourth quarter deposition averages may be found in table 6.

TABLE 6.—TOTAL DEPOSITION AT BERKELEY SITE FOURTH QUARTER 1961

[Deposition in mμc/m²]

Sampling location	No. of samples	Alpha	Beta
Local area			
Building 4	16	0.170	467
All others	24	0.024	153
Perimeter	47	0.034	168

Acid wastes from two chemical laboratory buildings were sampled and analyzed before dilution and discharge through the main sewer system. The sewage data in table 7 were estimated from the results of the above analyses. It is assumed that these two buildings are the only significant sources of radioactive liquid wastes.

Surface water was sampled weekly or biweekly from two small streams on the laboratory site. Six nearby off-site creeks were also sampled every two or four weeks depending on the relative distance from the laboratory.

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Tap water samples were taken approximately every week and the analyses results are summarized in table 7 with the above water data.

TABLE 7.—WATER MONITORING, BERKELEY SITE

[Average concentration in $\mu\mu c$/liter]

Type of sample	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Tap water	10	0.04	2.0	11	0.04	5.1
On site streams	24	0.12	7.9	24	0.14	21.1
Off site streams	33	0.10	2.6	30	0.09	12.5
Sewage (estimated)	—	0.09	3.6	—	0.15	10.3

Livermore Site

The Livermore site of LRL is located 3 miles east of Livermore, California. Technical facilities include a small cyclotron, a two megawatt swimming pool reactor, and physics and chemistry operations associated with a weapons development program. The laboratory also operates Site 300 which is physically located about 20 miles southeast of Livermore.

Environmental survey samples are collected for the purpose of detecting changes from the normal concentrations of radionuclides that could be attributed to operations at the laboratory. Samples include air particulate, soil, water, and sewage plant products.

Air particulate samples are collected continuously from 11 sites within 5 miles of the LRL. Filters are changed weekly and analyses made for alpha and beta activity. Third and fourth quarter results of these locations are summarized in table 8. The third quarter averages of alpha and beta activity at Site 300 were <0.0014 and <0.0032 $\mu\mu c/m^3$, respectively.

TABLE 8.—AIR MONITORING, LIVERMORE SITE

[Average concentration in $\mu\mu c/m^3$]

Distance from lab.	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
0.5–1.0 miles	13	0.012	0.039	44	0.006	3.4
2–5 miles	13	0.012	0.045	135	0.007	3.2

Ground water samples are collected to insure that radioactivity is not entering underground water sources from laboratory operations. This underground water is the sole source of domestic water for the Livermore area and is also used for irrigation. All water used at Site 300 is drawn from an underground source which is geologically separated from Livermore water. Table 9 summarizes the quarterly results.

TABLE 9.—RADIOACTIVITY IN WELL WATER AT LIVERMORE SITE

[Average concentration in $\mu\mu c$/liter]

Sample source	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
LRL Site	65	<15	<100	51	8.2	68
Site 300	65	<15	<100	30	8.2	68
Livermore (city)	6	<15	<100	8	8.2	68

Numerous soil samples are taken from around the Livermore area to maintain a further check on air-borne radioactive particulates. Sewage from the laboratory and Livermore is processed into dry sludge used for agricultural soil conditioner. Therefore, samples are taken at the Livermore Sewage Treatment Plant to assure that the concentration of radioactivity in the sludge is no higher than the normal concentration in the soil. Results of soil and sewage sludge sampling are presented in table 10.

TABLE 10.—RADIOACTIVITY IN SOIL AND SLUDGE, LIVERMORE SITE

[Average concentration in $\mu\mu c$/g]

Sample	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Soil	39	<7.7	<52	54	4.5	38
Sludge*	10	<7.7	<52	3	4.5	38

*Livermore Sewage Plant.

LOS ALAMOS SCIENTIFIC LABORATORY 1960–1961

University of California
Los Alamos, New Mexico

The Los Alamos Scientific Laboratory (LASL), in cooperation with the U.S. Geological Survey, conducts a program of environmental monitoring to determine what effect

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Laboratory activities have on the local area. The Laboratory is located in an area of high elevation in northern New Mexico. The program includes air particulate sampling for alpha and beta activity, water assays for specific radioactive materials, and measurements of gamma radiation. Average annual rainfall is 18 inches and stream flow is seasonal, dependent on snow run-off and storm activity.

Radioactive wastes are released in small amounts to the atmosphere and stream beds or are buried in restricted burial areas. Disposal is governed by the geology of the area to minimize any possibility of long-lived radioactive material causing future contamination of drinking or irrigation water sources.

Air Monitoring

Daily sampling of beta activity in air at LASL showed results similar to the values reported throughout the United States. The 1961 average at the laboratory was 3.32 $\mu\mu c/m^3$. This may be compared with 4.22 $\mu\mu c/m^3$ for the 1961 average of 171 stations of the Public Health Service National Air Sampling Network.[1]

Air particulate sampling stations are also located at 24 sites throughout the area to monitor for long-lived alpha activity. Sampling is performed continuously for one week before the filters are removed and counted. The maximum reading at any station for one week during the two-year period was 0.02 $\mu\mu c/m^3$; the average was less than 0.004 $\mu\mu c/m^3$ (See table 1, line 4 for MPC).

Water Monitoring

Assays for plutonium and uranium are made on water samples taken from the Los Alamos environs including surface and ground water, supply wells, and test wells.

The Rio Grande and Rio Chama are sampled periodically. The results indicate a fairly constant uranium concentration of about 1 μμc/liter. Bi-monthly or semi-annual samples collected from seven intermittent surface water sources showed uranium concentrations similar to that of the river samples.

Thirteen supply wells and 8 test wells are also sampled. The majority of these wells contain the same uranium concentration as the river and surface sources. One exception is a deep supply well which has a concentration of about 10 μμc/liter.

No plutonium has been detected in any water sample taken from the above sources.

Gamma Radiation

Film badges are placed on stakes at approximately 100 locations throughout Los Alamos County to detect and measure any gamma radiation resulting from LASL activities. The badges are presently collected and read once each quarter.

During 1960, two stations received slightly more than 0.5 rem of gamma radiation and in 1961 readings of 7.13, 3.15, 2.00, 0.75, and 0.54 rem were obtained at five stations. However, all of these stations were immediately adjacent to a radiation facility and were located so that personnel could not have remained long enough in the area to receive an appreciable part of the total dose. The source of the above high readings was removed on December 13, 1961 and the measurements indicate that no individual of the population could have received over 0.5 rem of whole body radiation during a 12 month period.

NEVADA TEST SITE DETONATION SURVEILLANCE

Atomic Energy Commission

April 14 Event

A low yield nuclear device was detonated in an underground tunnel chamber at the Nevada Test Site on April 14, 1962. Immediately upon detonation, radioactive steam was vented from the mouth of the tunnel and from a fissure which occurred on the top of the mesa. Aircraft monitoring of the cloud indicated a heading of 20° from ground zero, and, by twenty-two minutes after detonation, the cloud had reached an altitude of 10,000 feet Mean Sea Level (MSL). The cloud held to this bearing, and it was tracked on the ground and in the air.

The U.S. Public Health Service personnel, under contract to the Atomic Energy Commission, conducted extensive off-site monitoring

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[1] *Radiological Health Data* 3:113 (April 1962).

TABLE 11.—AIR MONITORING FOLLOWING THE APRIL 14, 1962 EVENT, NTS

Location	Number of people	Sampling period			Radio-isotopes	Average concentration ($\mu\mu c/m^3$)
		Duration (hr.-min.)	Ending			
			Date	Time		
Diablo	5	6–50	April 14	1650	Iodine-131 Iodine-135	525 2,000
		14–0	April 15	0700	Iodine-131 Iodine-133 Iodine-135	17.3 87 [a] ND
Currant	[b] 50	24–0	April 15	0800	Iodine-131 Iodine-133 Iodine-135	400 2,100 ND

[a] ND means not detectable.
[b] Migrant farm population varies from 50–200 during summer and fall.

and have determined the following exposures to the off-site population:

At Diablo Maintenance Station (forty-four miles from the test site), five people were present when the cloud passed. They were wearing badges supplied on March 8, 1962. These badges were collected on April 25, 1962, and showed a total exposure of 55 to 65 mr. After subtracting the normal background dose from the total recorded, lifetime doses of approximately 28 to 38 mr were estimated as resulting from this event.

As the cloud was carried northward by prevailing winds, it arrived over Currant (population 50; 115 miles from NTS) at about $H + 7\frac{1}{2}$ hours. For a period of 30 minutes, the reading was above background, and the peak reading was 0.5 mr per hour. Air samples indicated the presence of slight but detectable quantities of fresh fission products, such as iodine–131, iodine–133, tellurium–132 and ruthenium–105.

Table 11 illustrates the amount of activity of radioiodine in the air monitored at populated areas. The periods of collection encompass the passage of the gaseous cloud.

May 19 Event

Following an underground nuclear detonation at the Nevada Test Site on May 19, 1962, radioactive gases were released. Gases escaped for a period of twenty minutes. These gases formed into a cloud and were carried north of the test site by the prevailing winds.

From off-site data collected, the highest measured gamma radiation in a location where people were known to be present was at Diablo, fifty-five miles north of the test site. The cloud arrived at $H + 1\frac{3}{4}$ hours, with a maximum ground reading of 1.5 mr/hr at $H + 2\frac{1}{2}$. By $H + 3\frac{1}{2}$, the reading was 0.5 mr/hr, and at $H + 7\frac{3}{4}$, readings were at background levels. The total exposure might have been about 1 mr, but this was considerably below the threshold of detection by the film badges worn.

Due to high surface wind speeds, this cloud was carried rapidly northward and had dispersed considerably by the time it passed to the west of Ely. Between 2:00 p.m. and 3:45 p.m., it was scarcely detectable above normal background.

Analysis of activated charcoal filters indicated the atmospheric concentrations of radioisotopes at the time of cloud passage shown in table 12.

Addenda

Additional information now is available from data collected after the March 5, 1962 event, a subsurface nuclear detonation at the Nevada Test Site that released activity to the atmosphere[a]. These data show that the highest concentrations found in air in a populated place were at Warm Springs, Nevada. The air sampler operating between 1020 and 1515 hours indicated a gross beta count of 1000 $\mu\mu c/m^3$,

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[a] These data are supplemental to the material appearing in *RHD*, May 1962, page 170.

TABLE 12.—AIR MONITORING FOLLOWING THE MAY 19, 1962 EVENT, NTS

Location	Sampling period			Radio-isotopes	Average concentration ($\mu\mu c/m^3$)
	Duration (hr.-Min.)	Ending			
		Date	Time		
Tempiute	7-00	May 19	1630	Iodine-131	[a] ND
				Iodine-133	[b] —
				Iodine-135	ND
				Tellurium-132	ND
Penoyer	7-35	May 19	1635	Iodine-131	ND
				Iodine-133	3.7
				Iodine-135	6.2
				Tellurium-132	ND
Diablo	6-15	May 19	1540	Iodine-131	ND
				Iodine-133	3.2
				Iodine-135	12
				Tellurium-132	ND
Diablo	18-45	May 20	1030	Iodine-131	ND
				Iodine-133	0.69
				Iodine-135	1.40
				Tellurium-132	ND
Fallini	24-00	May 20	0615	Iodine-131	ND
				Iodine-133	ND
				Iodine-135	ND
				Tellurium-132	ND
Currant	10-45	May 20	0645	Iodine-131	516
				Iodine-133	23
				Iodine-135	18
				Tellurium-132	ND
Lund	5-30	May 19	1630	Iodine-131	ND
				Iodine-133	[b] —
				Iodine-135	ND
				Tellurium-132	ND
Ely	5-00	May 19	1400	Iodine-131	ND
				Iodine-133	ND
				Iodine-135	ND
				Tellurium-132	ND

[a] ND means not detectable.
[b] Detected but not quantitated.

16 $\mu\mu c/m^3$ of tellurium–132, 6.9 $\mu\mu c/m^3$ of iodine–131, 187 $\mu\mu c/m^3$ of iodine–133 and 275 $\mu\mu c/m^3$ of iodine–135 on the filter and 33.7 $\mu\mu c/m^3$ of iodine–133 and 73.5 $\mu\mu c/m^3$ of iodine–135 on the charcoal cartridge.

Based on dose rate readings, the estimated maximum exposure received off-site was approximately 1.7 mr to two persons at Clark's Station. (Film badges have a threshold of recording at 30 milliroentgens, and it is difficult to estimate accurately such low doses from survey meter readings.) The internal exposure due to inhalation was a small fraction of the total external exposure.

Reported Nuclear Detonations

September 1962

Summary information on announced nuclear detonations during the last month is indicated in the table below. Not all detected U.S.S.R. tests are necessarily announced by the Atomic Energy Commission. The AEC has indicated in general announcements that additional detonations have been detected in both the Fall 1961 U.S.S.R. test series and during the recent U.S.S.R. testing. The AEC announced by specific press releases 31 tests in the Fall 1961 series, and indicated in more recent press releases additional tests which brought the series' total to approximately 50. During the current U.S.S.R. testing activities, a similar reporting procedure is being used by AEC.

Radiological Health Data summarizes all available specific announcements of nuclear tests during each month preceding publication. Numbers are assigned to only those U.S.S.R. tests which have been announced since the termination of the test moratorium in 1961.

Corrections for the July 1962 Reported Nuclear Detonations: (1) U.S. test number 67 (Project Sedan) on July 6 at the Nevada Test Site was incorrectly reported as having a yield range of 1,000 kilotons; the correct yield range for this test is 100 kilotons. "Project Sedan" is part of the Commission's Plowshare Program in which peaceful uses for nuclear explosives are being explored. (2) The July 9 high altitude U.S. test has been called "Starfish" and its yield range previously given as megaton is specified as 1.4 megatons.

Test number	Location	Date (1962)	Yield range*	Type of test
REPORTED U.S.S.R. DETONATIONS				
41	Novaya Zemlya	September 2	Intermediate	Atmospheric
42	Novaya Zemlya	8	Megaton	Atmospheric
43	Novaya Zemlya	15	Low megaton	Atmospheric
44	Novaya Zemlya	16	Low megaton	Atmospheric
45	Novaya Zemlya	18	Low megaton	Atmospheric
46	Novaya Zemlya	19	Multi-megaton	Atmospheric
47	Novaya Zemlya	21	Low megaton	Atmospheric
48	Novaya Zemlya	25	30 megatons	Atmospheric
49	Novaya Zemlya	27	Less than 30 megatons	Atmospheric
REPORTED U.S. DETONATIONS				
79	Nevada Test Site	September 14	Low yield	Underground
80	Nevada Test Site	20	Low yield	Underground
81	Nevada Test Site	29	Low yield	Underground

* Low yield range has been announced as less than 20 kilotons yield; intermediate yield is in the range of 20 kilotons up to 1 megaton; and low megaton yield is in the range from 1 to several megatons.

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Announcement of Current Training Activities

Public Health Service

November 1962-May 1963

Short courses, designed primarily for public health personnel interested in acquiring basic information in radiological health, are again being offered by the Division of Radiological Health, Public Health Service. These courses cover a broad range of subjects dealing with the prevention and control of radiation hazards.

Extending from one week to ten-weeks duration, courses are given at the Robert A. Taft Sanitary Engineering Center (SEC), Cincinnati, Ohio; the Radiological Health Laboratory (RHL), Rockville, Maryland; the Southwestern Radiological Health Laboratory (SWRHL), at Las Vegas, Nevada; the Southeastern Radiological Health Laboratory (SERHL), Montgomery, Alabama; and the Northeastern Radiological Health Laboratory (NERHL), Winchester, Massachusetts.

Below is a list of courses available for the remainder of the training year (course numbers in parentheses):

Nov. 5-16, 1962	Occupational Radiation Protection (212) SEC
Nov. 26-30, 1962	Radioactive Pollutants in Water (195) SEC
Nov. 26-Dec. 7, 1962	Basic Radiological Health (211) RHL
Dec. 3-7, 1962	Radionuclides in Water (222) SEC
Dec. 3-14, 1962	Basic Radiological Health (211) SERHL
Dec. 10-14, 1962	Measurement of Airborne Radioactivity (417) SEC
Dec. 10-14, 1962	Medical X-ray Protection (213) RHL
Jan. 7-Mar. 15, 1963	Engineering Aspects of Radiological Health (231) SEC
Jan. 7-18, 1963	Basic Radiological Health (211) SEC
Jan. 7-18, 1963	Medical Aspects of Radiological Health (201) RHL
Jan. 21-Feb. 1, 1963	Occupational Radiation Protection (212) SEC
Jan. 28-Feb. 8, 1963	Basic Radiological Health (211) RHL
Feb. 4-22, 1963	Environmental Radiation Surveillance (244) SEC
Feb. 25-Mar. 7, 1963	Reactor Safety and Hazards Evaluation (233) SEC
Mar. 11-15, 1963	Medical X-ray Protection (213) SEC or RHL
Feb. 11-15, 1963	Medical X-ray Protection (213) RHL
Feb. 11-22, 1963	Basic Radiological Health (211) SWRHL
Feb. 25-Mar. 1, 1963	Management of Nuclear Emergencies (234) SWRHL
Mar. 18-May 24, 1963	Engineering Aspects of Radiological Health (231) SEC
Mar. 18-29, 1963	Basic Radiological Heath (211) SEC
April 1-12, 1963	Occupational Radiation Protection (212) SEC
April 15-May 3, 1963	Environmental Radiation Surveillance (244) SEC
May 6-16, 1963	Reactor Safety and Hazards Evaluation (223) SEC
May 6-16, 1963	Basic Radiological Health (211) SEC
May 20-24, 1963	Medical X-ray Protection (213) SEC or RHL
Mar. 18-29, 1963	Basic Radiological Health (211) RHL
April 1-5, 1963	Medical X-ray Protection (213) RHL
April 15-26, 1963	Basic Radiological Health (211) RHL
April 29-May 3, 1963	Medical X-ray Protection (213) RHL
May 13-17, 1963	Radiological Health for Nurses (203) RHL
May 20-24, 1963	Radionuclides in Foods (340) SEC
To be announced	Sanitary Engineering Aspects of Nuclear Energy (225) SEC

For further information on SEC courses, contact the Chief, Training Program, Robert A. Taft Sanitary Engineering Center. Additional details on courses offered at Rockville, Maryland; Las Vegas, Nevada; Winchester, Massachusetts; and Montgomery, Alabama, are available from the Chief, Training Branch, Division of Radiological Health, 1901 Chapman Avenue, Rockville, Maryland.

RADIOLOGICAL HEALTH DATA

VOLUME III, NUMBER 11
NOVEMBER 1962

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

50¢

SPECIAL REPORT

In a letter dated August 17, 1962, to the Chairman of the Joint Committee on Atomic Energy, Federal Radiation Council (FRC) Chairman Anthony J. Celebrezze set forth the FRC views on fallout levels due to nuclear weapons testing. On September 17, 1962, the FRC released to the public its position on current fallout levels. The FRC statement is reprinted in its entirety below.

Radiation protection guides prepared by the Federal Radiation Council and published in the *Federal Register*, September 26, 1961 established a graded series of appropriate actions related to three ranges of transient daily rates of intake of radioactive materials by exposed population groups. Some have interpreted this guidance as indicating that action in the form of preventive health measures must be taken when upper levels of Range II were reached.

An extensive national surveillance program provides the basis for a continual determination of the levels of radioactivity in air, water, soil, and milk and other foods. In some localities in the United States average annual intake values of radioactive iodine have approached the upper level of Range II and, in one locality, have slightly exceeded Range II. This had led to actions and proposed actions involving countermeasures or preventive health measures. The Federation Radiation Council does not recommend such actions under present circumstances.

Although some evidence has recently become available that the risks associated with exposures within the levels expressed by the guides for radioactive iodine may be even less than had been anticipated, it is not proposed at this time to change the guides. They were primarily devised for the industrial field and one of the most important reasons for their selection, the relative feasibility of compliance, still exists.

The Council believes, based on competent scientific advice, that any possible health risk which may be associated with exposures even many times above the guide levels would not result in a detectable increase in the incidence of disease.

The Radiation Protection Guides are not a dividing line between safety and danger in actual radiation situations nor are they alone intended to set a limit at which protective action should be taken or to indicate what kind of action should be taken. As applied to fallout, guides can be used as an indication of when there is a need for detailed evaluation of possible exposure risks and when there is a need to consider whether any protective action should be taken under all the relevant circumstances.

The Council believes that individual fallout situations require individual evaluation before specific action is taken. Such an evaluation must involve a careful examination of the source and magnitude and duration of the probable exposure levels as well as the health significance of these probable exposures balanced against the total impact of health protection measures.

Radiation exposures anywhere near the guides involve risks so slight that countermeasures may have a net adverse rather than favorable effect on the public well-being. The judgment as to when to take action and what kind of action to take to decrease exposure levels involves consideration of all factors.

The Federal Radiation Council recognizes the need for additional guidance related to fallout. The Council has directed appropriate Federal agencies to keep it continuously advised on the fallout situation, particularly with respect to local situations requiring evaluation. The Council, acting through its member agencies will, when requested, provide consultation and technical assistance in the event that there is concern about fallout levels in any part of the country.

In addition, the Federal Radiation Council will prepare a report on fallout summarizing the known physical phenomena, the health implications, the present surveillance network, and discussing the applicability of possible countermeasures. The Council, in consultation with experts within and outside the Government, including members of the National Academy of Sciences' Committees on Biological Effects of Atomic Radiation and the National Committee on Radiation Protection and Measurements, is continually examining the criteria upon which action involving preventive health measures might properly be taken. From time to time, as in the past, the Council will issue reports in this area to assist responsible authorities and to inform the public.

ADVANCE REPORT

Reports during October 1962 to the Public Health Service's Radiation Surveillance Center continued to indicate widespread occurrence of fresh fallout over the continental United States, including Alaska.

The Radiation Surveillance Network daily-reported field estimates of gross beta activity in air show increased levels of activity in the Southwest and West until October 10. On October 16, higher air activity levels were again reported. By October 23 these levels covered most of the nation. They then declined through the balance of October. During the period October 15-26, iodine–131 levels of 100 μμc/liter or more were found in precipitation from Salt Lake City, Utah, to Presque Isle, Maine and from Nashville, Tennessee, to the Great Lakes. The highest concentration was at Winchester, Massachusetts, with 600 μμc/liter of iodine–131 two days after collection on October 24.

During October the Public Health Service's Pasteurized Milk Network monthly tabulation of the Network's 62 stations showed an average daily iodine–131 concentration of 60 μμc/liter —the same as in September. However, 46 stations were above 20 μμc/liter compared to 40 stations during September. Of these 46 stations the following 12 stations had October monthly averages for iodine–131 of 100 μμc/liter or more:

Station	μμc/liter of milk	Station	μμc/liter of milk
Palmer, Alaska	270	Syracuse, New York	100
Chicago, Illinois	126	Minot, North Dakota	100
Des Moines, Iowa	120	Cleveland, Ohio	100
Detroit, Michigan	120	Pittsburgh, Pennsylvania	110
Minneapolis, Minnesota	100	Burlington, Vermont	100
New York, New York	130	Milwaukee, Wisconsin	140

SECTION I.—AIR AND PRECIPITATION

Fission Product Beta Activity in Airborne Particulates and Precipitation

Measurements of gross beta activity of airborne particulates and precipitation are among the earliest and most sensitive indicators of increases of fission product activity in the environment. However, a direct evaluation of biological effects is not possible from these data alone.

Of the several networks or sampling programs making such measurements, the Radiation Surveillance Network and the 80th Meridian (West) Sampling Program are represented in the following reports.

RADIATION SURVEILLANCE NETWORK
August 1962

Division of Radiological Health,
Public Health Service

The Public Health Service Radiation Surveillance Network (RSN) was established in 1956 in cooperation with the Atomic Energy Commission primarily to provide a means of promptly determining increasing levels of radioactivity in air and precipitation due to fallout from nuclear weapons tests. Prior to September 1961, the Network consisted of 45 stations. Following the September 1961 resumption of nuclear weapons testing by the U.S.S.R., the Network was expanded over a period of several months to 72 stations, whose locations are shown in figure 1.

Air

Daily 24–hour air samples are collected by a high volume air sample with a 4-inch diameter carbon-loaded cellulose dust filter. Field measurements with a portable survey meter enable the station operator to estimate the amount of beta activity in airborne particulates at the station 5 hours after collection by comparison with a known Sr^{90}–Y^{90} source. This 5–hour delay eliminates interference from naturally-occurring radon daughters. Each operator then reports his field estimate by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C., to provide a daily national report.

The filters are then forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3–day aging of the sample eliminates interference from naturally–occurring radon and thoron daughters. The two counts, separated by a 7–day interval, make possible the estimation of the age of fission products and extrapolation of the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2} =$ constant).[1]

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[1] In this expression, A is the activity at time T after fission product formation. Units are arbitrary.

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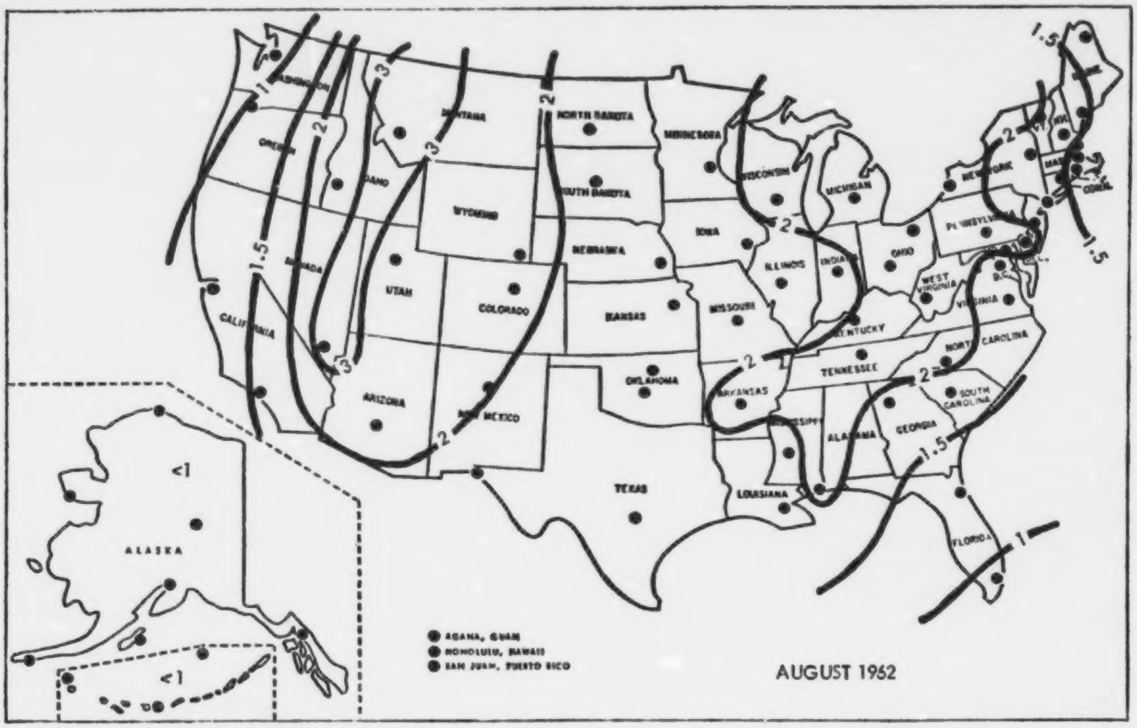

AUGUST 1962
AGANA, GUAM
HONOLULU, HAWAII
SAN JUAN, PUERTO RICO
ALASKA
<1
<1
1
1.5
2
3
1.5
2
1.5
1
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
CONN.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$)

Although gross beta concentration is usually presented without reference to age, it is apparent that fission product activity is more adequately described when the age parameter is also given. Because of the difficulty in determining a meaningful monthly average age of fission products, such data have not yet been presented with RSN data in *RHD*.

The average fission-product beta concentrations in surface air during August 1962 as determined by laboratory analysis are tabulated in table 1 and presented by means of concentration contours in figure 1. Experience has shown that field estimates are generally comparable to laboratory analyses, except at low levels, where the former are usually higher because of the relatively greater contribution of the thoron daughters.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels having collection areas of 0.4 m². A 500 ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

The August 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and millimicrocuries per square meter ($m\mu c/m^2$) are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through August 1962, are shown in figure 2.

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, AUGUST 1962

[Concentrations in $\mu\mu c/m^3$]

Station location		Number samples	Maximum	Minimum	Average[a]
Alaska	Adak	31	2.8	<0.10	0.5
	Anchorage	30	3.0	<0.10	0.7
	Attu Island	31	5.0	<0.10	0.8
	Fairbanks	6	1.4	0.20	0.9
	Juneau	23	3.5	<0.10	0.8
	Kodiak	29	6.6	<0.10	0.9
	Nome	29	2.3	<0.10	0.5
	Point Barrow I.	23	6.0	<0.10	0.9
	St Paul Island	29	4.2	<0.10	0.5
Ariz.	Phoenix	29	12.4	.99	2.4
Ark.	Little Rock	31	4.1	0.64	2.0
Calif.	Berkeley	31	4.9	<0.10	1.0
	Los Angeles	26	3.6	0.67	1.5
Colo.	Denver	30	13.0	0.87	2.6
Conn.	Hartford	29	3.8	0.17	1.6
Del.	Dover	22	4.8	0.70	2.5
D.C.	Washington	31	4.0	0.37	1.7
Fla.	Jacksonville	30	4.3	0.12	1.1
	Miami	31	2.7	0.30	0.9
Ga.	Atlanta	31	5.7	0.86	1.9
Guam	Agana	22	0.9	<0.10	0.3
Hawaii	Honolulu	31	1.3	0.11	0.6
Idaho	Boise	30	4.3	1.7	2.8
Ill.	Springfield	29	3.6	0.44	1.7
Ind.	Indianapolis	31	4.6	0.15	2.0
Iowa	Iowa City	30	4.0	0.53	1.7
Kans.	Topeka	30	4.4	0.26	1.7
Ky.	Frankfort	31	6.5	0.11	2.0
La.	New Orleans	31	3.0	0.29	1.3
Maine	Augusta	29	3.2	0.32	1.6
	Presque Isle	30	3.1	<0.10	1.4
Md.	Baltimore	29	6.1	0.25	2.3
	Rockville	22	4.8	0.45	1.9
Mass.	Lawrence	31	2.8	0.14	1.4
	Winchester	31	3.8	0.16	1.3
Mich.	Lansing	30	7.3	0.44	2.3
Minn.	Minneapolis	31	4.0	0.53	1.6
Miss.	Jackson	27	3.4	0.36	1.6
	Pascagoula	21	4.0	0.24	2.0
Mo.	Jefferson City	31	3.6	0.64	1.8
Mont.	Helena	31	9.6	1.0	3.1
Nebr.	Lincoln	27	3.6	0.66	1.7
Nev.	Las Vegas	27	18.5	1.35	3.2
N.H.	Concord	23	3.1	0.24	1.8
N.J.	Trenton	31	4.2	0.11	1.5
N. Mex.	Santa Fe	30	5.9	1.16	2.1
N.Y.	Albany	27	4.3	0.31	1.8
	Buffalo	30	4.9	0.86	2.3
	New York	18	2.8	0.15	1.6
N.C.	Gastonia	31	9.2	0.37	2.5
N.D.	Bismarck	30	4.9	0.67	1.9
Ohio	Columbus	31	6.4	0.67	2.4
	Painesville	30	5.5	0.80	2.3
Okla.	Oklahoma City	29	5.2	0.66	1.8
	Ponca City	29	1.7	0.18	0.8
Oreg.	Portland	31	3.1	0.44	1.2
Pa.	Harrisburg	25	7.3	0.56	2.3
P.R.	San Juan	30	1.7	0.27	0.8
R.I.	Providence	29	4.6	<0.10	1.5
S.C.	Columbia	30	4.9	0.37	1.4
S.D.	Pierre	31	5.3	0.92	1.9
Tenn.	Nashville	31	6.6	0.75	2.6
Tex.	Austin	30	4.5	0.41	1.7
	El Paso	31	4.1	0.80	1.7
Utah	Salt Lake City	31	8.8	1.3	2.9
Vt.	Barre	31	4.3	0.39	2.1
Va.	Richmond	31	3.9	0.34	1.6
Wash.	Seattle	31	2.5	0.14	0.6
W. Va.	Charleston	25	4.3	0.25	2.1
Wis.	Madison	30	5.2	0.73	2.3
Wyo.	Cheyenne	31	7.1	0.87	2.4
Network average					1.7

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION RSN AUGUST 1962

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
Alaska	Adak	[*]—	—
	Anchorage	768	45
	Attu	—	—
	Fairbanks	—	—
	Juneau	526	68
	Kodiak	—	—
	Nome	—	—
	Point Barrow I.	—	—
	St. Paul Island	—	—
Ariz.	Phoenix	—	—
Ark.	Little Rock	420	29
Calif.	Berkeley	3,143	8.8
	Los Angeles	—	—
Colo.	Denver	1,181	16
Conn.	Hartford	616	61
Del.	Dover	—	—
D.C.	Washington	3,716	6.8
Fla.	Jacksonville	403	42
	Miami	404	59
Ga.	Atlanta	—	—
Guam	Agana	—	—
Hawaii	Honolulu	—	—
Idaho	Boise	—	—
Ill.	Springfield	—	—
Ind.	Indianapolis	422	45
Iowa	Iowa City	381	13
Kans.	Topeka	673	111
Ky.	Frankfort	904	27
La.	New Orleans	554	69
Maine	Augusta	1,651	100
	Presque Isle	496	53
Md.	Baltimore	—	—
	Rockville	—	—
Mass.	Lawrence	477	34
	Winchester	1,151	69
Mich.	Lansing	843	26
Minn.	Minneapolis	634	77
Miss.	Jackson	383	16
	Pascagoula	409	30
Mo.	Jefferson City	451	16
Mont.	Helena	2,013	51
Nebr.	Lincoln	467	27
Nev.	Las Vegas	—	—
N.H.	Concord	—	—
N.J.	Trenton	352	27
N. Mex.	Santa Fe	1,254	7.3
N.Y.	Albany	524	4.9
	Buffalo	530	23
	New York	—	—
N.C.	Gastonia	533	25
N. Dak.	Bismarck	1,547	38
Ohio	Columbus	960	24
	Painesville	619	36
Okla.	Oklahoma City	—	—
	Ponca City	471	32
Ore.	Portland	432	6.2
Pa.	Harrisburg	641	33
P.R.	San Juan	396	53
R.I.	Providence	552	36
S.C.	Columbia	451	37
S. Dak.	Pierre	1,423	16
Tenn.	Nashville	460	26
Tex.	Austin	—	—
	El Paso	—	—
Utah	Salt Lake City	1,864	4.4
Vt.	Barre	703	50
Va.	Richmond	404	30
W. Va.	Charleston	525	19
Wash.	Seattle	569	13
Wis.	Madison	1,090	58
Wyo.	Cheyenne	2,098	30

[*] Dash denotes no evaporated sample received.

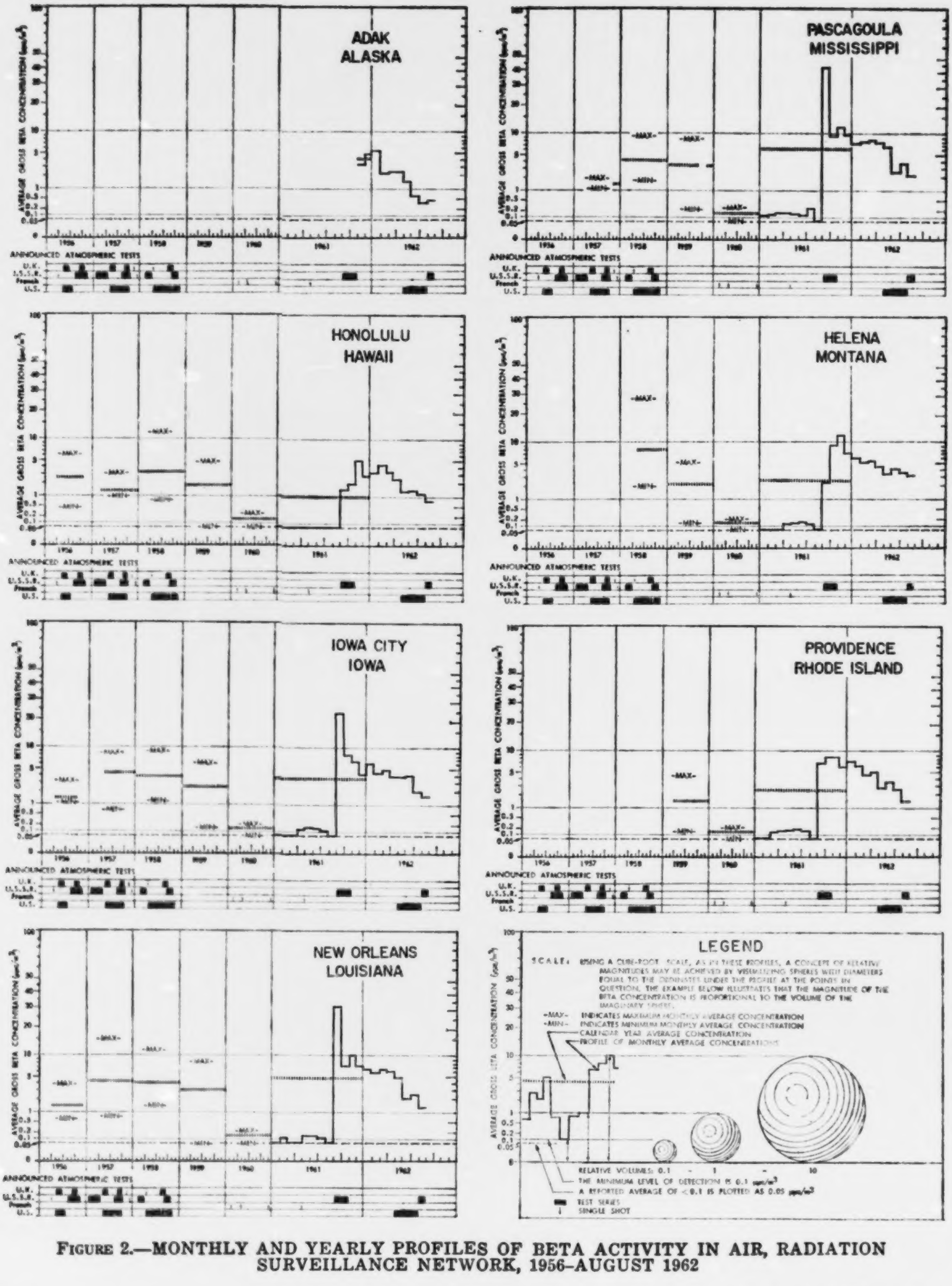


FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–AUGUST 1962

THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM
July 1962

U. S. Naval Research Laboratory

Radioactivity measurements of surface air samples collected at various sites near the 80th Meridian (West) have been made since 1956. Sampling locations are shown in figure 3. This program is operated by the U. S. Naval Research Laboratory (NRL) with the cooperation of interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile, which collect the samples and forward them to NRL for analysis. Partial financial support of this program is provided by the Division of Biology and Medicine, U. S. Atomic Energy Commission.

The sampling procedure involves drawing air continuously for a 7-day period, at a rate of approximately 1200 cubic meters per day through an 8-inch diameter, high efficiency filter, using a positive displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. Data are not extrapolated to time of collection.

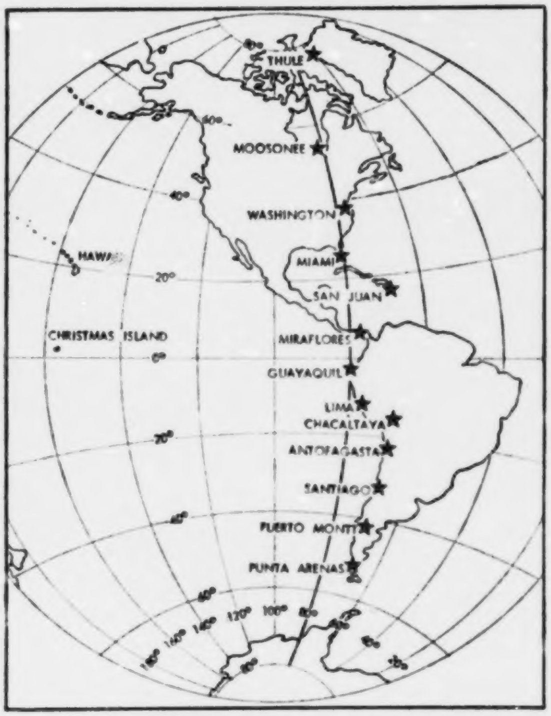

THULE
MOOSONEE
WASHINGTON
HAWAII
MIAMI
SAN JUAN
CHRISTMAS ISLAND
MIRAFLORES
GUAYAQUIL
LIMA
CHACALTAYA
ANTOFAGASTA
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
60°
40°
20°
0°
20°
40°
60°
180° 160° 140° 120° 100° 80° 60° 40° 20°

FIGURE 3.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

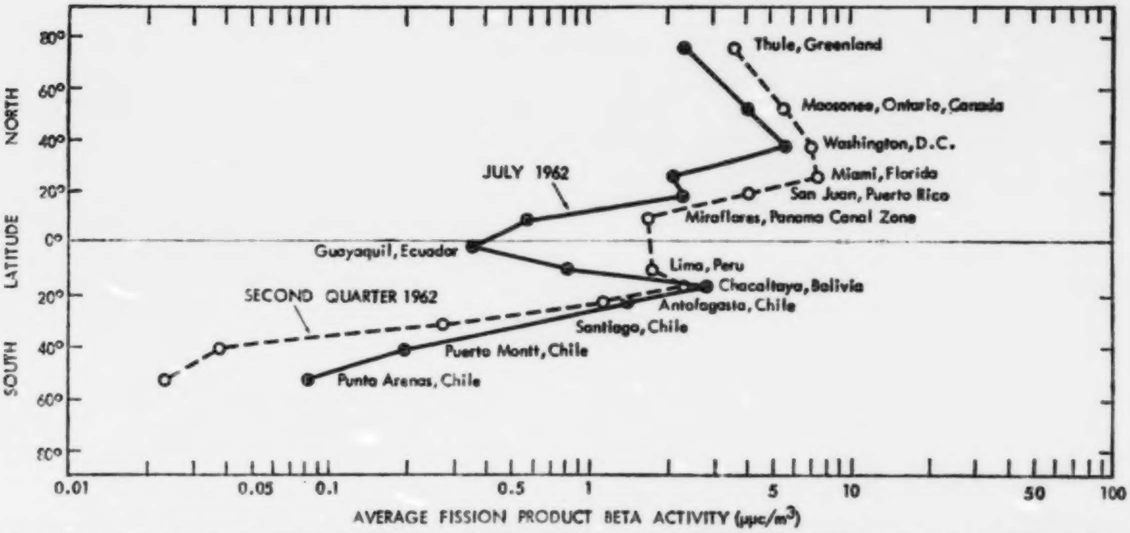


FIGURE 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENT OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST) JULY 1962

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL[a], JULY 1962

[Average concentrations in $\mu\mu c/m^3$]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil Ecuador	Miraflores, Panama, Canal Zone	San Juan, P. R.	Mauna Loa, Hawaii[c]	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1 2	0.057	0.079	[b]—	—	1.33	1.76	—	0.193	2.21	4.31	3.06	8.82	5.22	1.58
3 4 5 6 7 8 9	0.166	0.149	—	1.66	2.18	0.734	—	0.724	2.54	4.07	1.67	6.12	5.58	0.93
10 11 12 13 14 15 16	0.029	0.032	—	0.819	3.96	0.567	—	0.526	1.66 —	2.66	1.80	6.88	3.24	2.11
17 18 19 20 21 22 23	0.072	0.070	—	1.49	2.92	1.18	—	0.558	2.49	2.52	2.34	4.90	3.90	3.75
24 25 26 27 28 29 30	0.072	0.572	—	1.73	—	0.472	0.313	0.648	2.49	2.26	2.28	4.10	3.42	2.80
31	0.067	—	—	1.48	1.64	[illegible]	0.497	0.756	1.62	1.81		3.96	2.21	2.24
Weighted average	0.082	0.198	—	1.43	2.82	0.828	0.350	0.594	2.30	2.93	2.10	5.67	4.05	2.32

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period or that portion of the sampling period occurring in June 1962.

[b] Dash indicates samples were not received.

[c] Mauna Loa data has been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters) and about equally distant north and south of the equator.

Natural and Fission Product Radioactivity in Surface Air Particulates at Cincinnati, Ohio

July 16–August 10, 1962

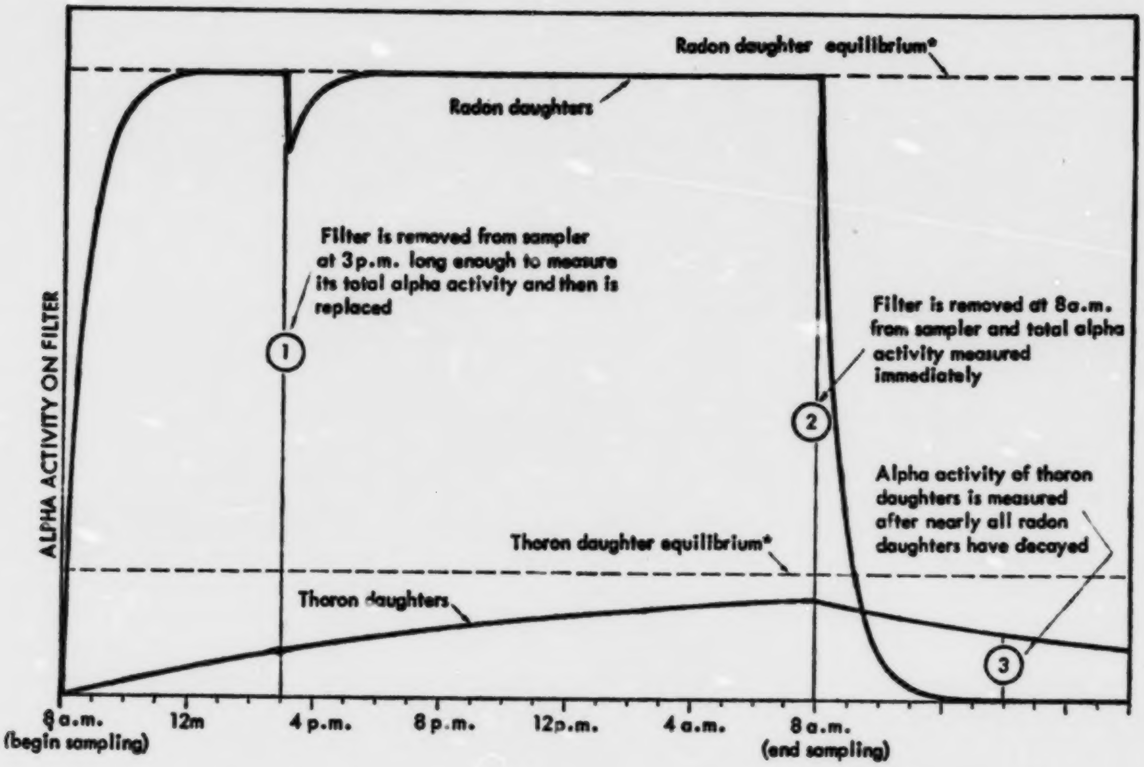
Division of Radiological Health, Public Health Service

The determination of natural radioactivity in the atmosphere is useful because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially-produced radionuclides. Some of the more important examples of naturally-occurring and artificially-produced airborne radioactivity are given in table 1. The physical state is important to selection of sampling procedure.

Radon and Thoron

The earth's crust contains trace amounts of naturally-occurring uranium and thorium, each of which decays through a series of radionuclides, ending finally in stable isotopes of lead. One of the radionuclides in the uranium series is the chemically inert gas, radon-222, commonly called "radon." In the thorium series, the inert gas decay product is radon-220, or "thoron." Some radon and thoron gases formed near the ground surface escape into the atmosphere before decaying to their particulate daughter products. Concentrations of radon and thoron in surface air depend on prevailing atmospheric conditions such as ambient temperature, wind and pressure, and on soil conditions such as moisture, porosity and temperature that affect the rate of diffusion of the gases through the soil.

Most of the natural radioactivity in surface air is due to radon and its daughters. Thoron and its daughters contribute less because of thoron's shorter half life which allows less time for diffusion through the pores of the soil and escape into the atmosphere. The natural



* Equilibrium values do not in fact remain constant throughout a 24-hour period but vary with changes of radon and thoron concentrations in air.

FIGURE 1.—IDEALIZED PROFILE OF ALPHA ACTIVITY ON FILTER DURING AND AFTER SAMPLING

radioactivity concentration in air shows a pronounced daily fluctuation. During a period of atmospheric inversion, such as often occurs in the early morning, radon and thoron tend to accumulate in the air near the ground surface. During periods of atmospheric turbulence, radon and thoron are dispersed in the atmosphere, leaving lower concentrations near the surface.

Measurement of radon and thoron concentrations in air may be accomplished by two general methods. The direct method involves the collection of radon and thoron gases by charcoal adsorption (*1*) while the indirect method utilizes the collection of airborne particulates, which include the radon and thoron daughter products, on the surface of a membrane filter. The choice of the indirect method for routine monitoring was made because of its simplicity, sensitivity, and low cost.

The measurement of radon and thoron by the indirect method is based on the assumption that radon and thoron in the atmosphere are in equilibrium with their daughters. Under these conditions, including the provision of a uniform flow of air, the particulate alpha activity (from the daughter products) retained on the membrane filter by a uniform flow of air may be theoretically related to the concentrations of radon and thoron in air. If radon and thoron activities in the air remain constant, the alpha activity on the filter while the sampler is in operation will reach 97 percent of equilibrium in 2.5 hours for radon daughters and in 53 hours for thoron daughters. The measurement of the activity by alpha scintillation, which is specific for alpha activity, eliminates interference from fission product beta activity.

The method used for the separate measurements of radon and thoron daughters is diagrammed in figure 1 representing the history of a filter during a typical 24-hour sampling period and for a period following its removal.

TABLE 1.—EXAMPLES OF AIRBORNE RADIOACTIVITY

Physical state	Natural: Nuclides (radiation)	Natural: α half life	Artificial (fission products)
Gaseous	Radon (α, γ) Thoron (α, γ)	3.8 days 54 seconds	Kr^{85}, Xe^{133}, volatile I^{131} (β, γ)
Particulates	Radon daughters (α, β, γ) Thoron daughters (α, β, γ)	0.5 hours 10.6 hours	Sr^{89}, Sr^{90}, Cs^{137}, I^{131} (β, γ)

At 3:00 p.m. the filter is removed momentarily from the sampler and counted. Although some thoron daughter activity is present, it is neglected and the activity is taken as radon daughter activity. The time of 3:00 p.m. was selected to represent the time of day most likely to have atmospheric turbulence and, therefore, lowest radon concentration in surface air. Radon and thoron concentrations often reach a maximum during an early morning atmospheric inversion condition. The 8:00 a.m. measurement of activity therefore approximates the daily maximum.

The measured alpha activities on the filter are adjusted to 100 percent equilibrium with factors based on duration of sampling period and decay time after removal of filter. (2) The equilibrium alpha activities due to the respective daughter products may in turn be converted to radon and thoron concentrations in air by the following expressions:

(a) radon $(\mu\mu c/m^3) = 6\ A_r/F$, and
(b) thoron $(\mu\mu c/m^3) = 0.45\ A_t/F$,

where A_r and A_t are the radon and thoron daughter alpha activities (dpm) respectively, and F is the air sampling rate in liters per minute at the end of the sampling period.

Table 2 shows daily calculated radon activities for 8 a.m. and 3 p.m. and thoron for 8 a.m.

TABLE 2.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS AT CINCINNATI, OHIO JULY 16—AUGUST 10, 1962

[concentrations in $\mu\mu c/m^3$]

End of sampling period		Rn^{222} 8 a.m.	Rn^{222} 3 p.m.	Rn^{220}	Beta activity
July	16	290	160	1.3	2.8
	17	330	200	2.3	2.9
	18	270	150	1.9	3.8
	19	700	110	3.9	4.0
	20	660	150	7.2	3.1
	23	150	110	3.8	4.2
	24	620	100	4.0	4.3
	25	300	110	4.6	3.2
	26	90	30	1.4	3.9
	27	720	90	6.5	3.9
	30	910	230	8.1	4.8
	31	850	210	8.4	3.2
August	1	700	110	4.7	3.6
	2	470	210	9.5	3.0
	3	1240	160	10.6	3.4
	6	610	140	8.3	2.9
	7	350	190	2.5	1.7
	8	300	150	8.7	1.2
	9	400	130	3.3	2.5
	10	390	80	3.3	2.8
Average		511	146	5.2	3.37
Range of errors due to counting for daily contrations above (2 standard deviations)		±17 to ±62	±10 to ±27	±0.4 to ±1.1	±0.06 to ±0.13

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Fission Product Activity

The membrane filter used for the determination of radon and thoron is retained several days to allow for the decay of thoron daughters. At that time the beta activity is measured. This activity represents fission products and is reported in table 2.

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SECTION II.—FOOD

Strontium–90, Calcium, and Stable Strontium in Tri-City Infant Diets*

August–October 1961

J. Rivera

Health and Safety Laboratory, U.S. Atomic Energy Commission

Because the first year of life is a period of rapid bone growth, dietary intake of strontium–90 and calcium during this period is of critical importance in determining the ultimate body burden of strontium–90. Estimates of these intakes by infants living in the New York City area were reported for 1959 and 1960 in HASL–111 (*1*).

In 1961, a limited bone sampling program was started by the Health and Safety Laboratory in coordination with the Tri-City Diet Study, whose aim is to establish bone/diet observed ratios for the average population at New York City, Chicago, and San Francisco. Since there was doubt as to whether the Sr^{90}/Ca ratio of the average diet was the same as that in infant diets, infant diet sampling in 1961 was extended to include Chicago and San Francisco, as well as New York City. Results of the August 1961 diet surveys are reported in table 1.

Measurement of the stable strontium content of these baby foods were also made, so that subsequently bone/diet observed ratios using stable strontium could be computed. Results of the stable strontium measurements are reported in table 2.

Strontium–90 and Calcium

The diet components listed in table 1 are composites of different varieties of foods and brands. Consumption figures for the individual diet components were taken from the compilation of Klein (*2*).

The data obtained from New York City may be compared with what was found there in 1959 and 1960. Since the calcium concentrations in the 1960 sampling were inexplicably low, it is better to compare strontium–90 intake levels rather than Sr^{90}/Ca ratios. In August 1959, the strontium–90 intake of New York City infants was calculated to be 18 μμc/day. In August 1960, it dropped to 7.9 μμc/day and, as can be seen from table 3, the intake was 11.7 μμc/day in August 1961. Although the decline in the strontium–90 intake between 1959 and 1960 was probably real, the elevation of the intake between 1960 and 1961 may not be. It is hazardous to compare diet estimates made from a single sampling, since it is not known how representative an im-

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* U.S. Atomic Energy Commission, *Quarterly Summary Reports, HASL–122* and *HASL–127*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1 and July 1, 1962), price $3.00.

TABLE 1.—STRONTIUM-90 AND CALCIUM INTAKE BY ONE YEAR OLD INFANTS*

Food Category	Annual consumption kg/year	New York City				Chicago				San Francisco			
		Calcium (g/kg)	Strontium-90 (μμc/kg)	Calcium (g/yr)	Strontium-90 (μμc/yr)	Calcium (g/kg)	Strontium-90 (μμc/kg)	Calcium (g/yr)	Strontium-90 (μμc/yr)	Calcium (g/kg)	Strontium-90 (μμc/kg)	Calcium (g/yr)	Strontium-90 (μμc/yr)
Cereals	8	7.56	11.6	60	93	11.69	15.4	94	123	5.61	4.8	45	38
Vegetables	23	0.19	8.3	4	191	0.18	5.4	4	124	0.35	4.7	8	108
Fruits	23	0.04	1.2	1	28	0.08	1.5	2	35	0.04	0.7	1	16
Meats	17	**0.12	2.4	2	41	**0.12	1.5	2	26	**0.12	2.4	2	41
Formula milks	37	1.64	11.0	61	407	1.54	13.8	57	511	1.31	10.7	48	396
Evaporated milks	137	2.34	25.7	321	3521	2.14	11.7	293	1603	2.10	4.8	388	658
Totals	----------	--------	--------	449	4281			457	2422			392	1257

* Samples taken in August 1961.
** Estimated from August 1960 analysis of New York City sample.

portant item such as milk was at the time of a given sampling. The data do show, however, that there was no significant difference between the Sr^{90}/Ca ratio of the diets estimated for the average population, and the ratio in the diets consumed by infants during their first year of life, at each of the three cities at the time of sampling.

There is a possibility that differences may later be exhibited between these ratios due to differences in the time lag between the production and consumption of infant and adult foods. It is hoped that this effect may be seen by determining Sr^{89}/Sr^{90} ratios in the various components of infant and adult diets that will be obtained during periods of expected heavy fallout in 1962.

Stable Strontium

The stable strontium analyses reported in table 2 were determined by neutron activation analysis. The accuracy of this method is estimated to be ± 5 percent.

At each of the cities, the diet component with the highest concentration of stable strontium was cereals. Evaporated milk was the diet component contributing the greatest amount of stable strontium to the total intake during the first year of life.

The total intake of stable strontium by the infants in San Francisco was considerably higher than that of the infants in New York City or Chicago. This was due principally to the higher concentration of stable strontium in

TABLE 2.—STABLE STRONTIUM AND CALCIUM INTAKE BY ONE YEAR OLD INFANTS*

City	Food category	kg/yr	Strontium (ppm)	% ash	Strontium (mg/kg)	Strontium (mg/yr)	Calcium (g/yr)	Strontium (mg/g Ca)
New York City	Cereals	8	129	4.62	5.96	47.7	60	0.8
	Vegetables	23	216	1.09	2.35	54.1	4	13.5
	Fruits	23	132	0.45	0.59	13.8	1	13.8
	Meats**	17	25.3	1.14	0.29	4.9	2	2.5
	Formula Milks	37	97.1	1.05	1.02	37.7	61	0.6
	Evaporated Milks	137	53.7	1.54	0.83	113.7	321	0.4
						271.9	449	(0.61)
Chicago	Cereals	8	138	6.69	9.23	73.8	94	0.8
	Vegetables	23	98.7	1.03	1.02	23.4	4	5.9
	Fruits	23	114	0.45	0.51	11.7	2	5.9
	Meats**	17	25.3	1.14	0.29	4.9	2	2.5
	Formula Milks	37	63	1.09	0.69	25.5	57	0.4
	Evaporated Milks	137	50.0	1.54	0.77	105.5	293	0.4
						244.8	452	(0.54)
San Francisco	Cereals	8	110	3.96	4.71	37.7	45	0.8
	Vegetables	23	255	0.97	2.47	56.8	8	7.1
	Fruits	23	133	0.38	0.51	11.7	1	11.7
	Meats**	17	25.3	1.14	0.29	4.9	2	2.5
	Formula Milks	37	70.7	1.30	0.92	34.0	48	0.7
	Evaporated Milks	137	122	1.60	1.95	267.2	288	0.9
						412.3	392	(1.05)

* Based on August 1961 samples.
** New York City 1960 sample.

TABLE 3.—STRONTIUM-90 INTAKE AND STRONTIUM-90 CALCIUM RATIO FOR ADULTS AND INFANTS, 1961

Strontium-90	New York City		Chicago		San Francisco	
	Adult	Infant	Adult	Infant	Adult	Infant
	August 1961	August 1961	October 1961	August 1961	September 1961	August 1961
Intake ($\mu\mu c$/day)	9	11.7	6.2	5.6	2.6	3.4
Sr^{90}/Ca Ratio ($\mu\mu c$/g Ca)	8.6	9.5	5.9	3.4	2.5	3.2

evaporated milk purchased in San Francisco. Preliminary data on the stable strontium content of foods constituting adult diets in the three cities also show increased stable strontium concentrations in foods purchased in San Francisco as compared to those purchased in New York City (*3*). The stable strontium content of fresh liquid milk from San Francisco was 1.00 mg Sr/kg, while New York City milk had a concentration of 0.38 mg Sr/kg.

The estimated ratios of 0.61 mg Sr/g Ca in the New York City diet and 0.54 mg Sr/g Ca for the Chicago diet are about the same as the 0.57 mg Sr/g Ca estimated in the United Kingdom by Bryant and Loutit (*4*) for the diet of one year old infants. The estimated ratio of stable strontium to calcium in the San Francisco diet of 1.05 mg Sr/g Ca, however, is considerably greater than that for New York City, Chicago, or the United Kingdom.

When data on the strontium-90, stable strontium, and calcium concentrations in infant bones from the three cities have been obtained, it should be possible to calculate bone/diet observed ratios using both stable and radioactive strontium values. It will be interesting to see if the calculated observed ratios using stable and radioactive strontium are the same for San Francisco as for the other two cities, since the stable strontium intake at San Francisco was higher than in the other cities, while the strontium-90 intake was lower.

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(*2*) Klein, S.: Estimate of Strontium-90 in the Diet of New York City Infants Nurtured on Commercially Processed Baby Foods and Milk Purchased in August 1959 and January 1960, *Quarterly Summary Report, HASL-84*, p. 230, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1960), price $3.00.

(*3*) Rivera, J.: Stable Strontium in Tri-City Diets, *Quarterly Summary Report, HASL-131*, p. 230-4, Office of Technical Services, Department of Commerce, Washington 25, D.C. (October 1, 1962), price $3.50.

(*4*) Bryant, F. J. and J. B. Loutit: *Human Bone Metabolism Deduced from Strontium Assays, AERE-R 3718*, Her Majesty's Stationery Office, London (1961).

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Strontium–90 in Baby Foods Prior to Resumption of Nuclear Testing, 1959–1961

Division of Pharmacology
Food and Drug Administration

This survey of the strontium–90 content of infant and junior foods was initiated in 1960 as a part of an overall analysis of strontium–90 in items of importance in the food chain. About 100 different samples representing 26 food items collected from growing or processing points in California, Michigan, New York, and North Carolina have been assayed. These samples reflect the fallout conditions which prevailed prior to the resumption of nuclear testing in September 1961. The radioassay procedure used for baby foods is similar to that used for other food samples (*1*).

TABLE 1.—STRONTIUM–90 CONTENT OF SELECTED BABY FOODS, 1959–1961

[μμc/kg]

Food	Number of samples	Mean	Range
Vegetables:			
Beets	1	4.8	
Beans, green	4	18	8.6–25
Carrots	5	1.6	0.4– 3.9
Peas	3	3.6	2.8– 4.1
Potatoes, sweet	4	4.6	3.4– 6.2
Spinach, creamed	3	7.9	5.3–11
Squash	5	6.2	0.8–18
Fruit:			
Applesauce	5	0.8	0.1– 1.2
Apricots with tapioca	2	0.7	0.0– 1.2
Bananas	2	0.3	0.2– 0.3
Peaches	6	0.5	0.0– 1.2
Pears	5	1.8	0.2– 3.9
Plums with tapioca	4	0.9	0.7– 1.3
Prunes with tapioca	1	1.3	
Meats:			
Beef and broth	3	1.0	0.6– 1.4
Chicken and broth	2	1.4	1.3– 1.4
Lamb and broth	2	0.5	0.4– 0.5
Pork and broth	1	0.1	
Veal and broth	3	0.8	0.5– 1.2
Grains:			
Barley cereal	1	7.0	
Corn flour	2	0.2	0.1– 0.3
High protein cereal	2	37	24 –49
Mixed cereal	3	2.0	1.5– 2.7
Oats			
flour	8	6.6	5.0–11
meal cereal	4	14	3.7–25
Rice			
cereal	4	2.7	1.8– 4.0
flour	1	0.9	
Soyflour	1	27	
Wheat			
flour	3	4.3	3.0– 5.6
germ	3	38	23 –46
gluten	2	26	6.1–46

Table 1 summarizes all data from the results of this survey. Portions of these data have been presented in previous issues of *Radiological Health Data*. The small number of samples in the survey prevents making comparisons of any differences on an individual food item or geographical basis between the 1959, 1960, and early 1961 growing seasons. Hence, table 1 includes all data for this period, grouped only by individual food items.

Although the number of samples is small, some general observations are apparent from the data. In the vegetable group, green beans and spinach contain the highest strontium–90 concentration, while carrots contain the least. Root vegetables contain less strontium–90 than green leafy vegetables. Little differences between strontium–90 content in varieties of fruits can be noted. However, it is observed that fruits, on the average, contain about one-seventh the strontium–90 content of vegetables. Meats and poultry also contain relatively little strontium–90.

Some cereals, such as wheat and oats, contain more strontium–90 in comparison to other foods in the survey. This relationship is also noted in the more extensive Food and Drug Administration surveys of all food items. The single value noted for soy flour may account for the relatively high strontium–90 concentrations in the 2 high protein cereal samples. Wheat germ is also of interest because it contains the highest strontium–90 concentration of all the babyfoods surveyed.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960	*August 1961*
1960	*December 1961*
1960 and 1961	*April 1962*

REFERENCES

(*1*) Strontium–90 in Raw and Processed Foods, *Radiological Health Data, 3*:320 (September 1962).

SECTION III.—MILK

Radionuclide Analyses of Pasteurized Milk

PASTEURIZED MILK NETWORK
July 1962

Division of Radiological Health
Division of Environmental Engineering and Food Protection
Public Health Service

Milk monitoring has been conducted by the Public Health Service since early 1957, when the first program was established to develop suitable sampling methods and radiochemical analytical procedures. Milk is produced every day throughout the year in practically every county of the United States. It can be readily checked in processing centers and is a good indicator of fallout in the diet. Raw milk was initially selected for investigation; however, it became evident that the milk actually consumed by the population should be included in a broader sampling program. The result was the initiation, in the first quarter of 1960, of a pasteurized milk network designed to provide data representative of the milk consumed in selected municipalities.

During July 1962, the surveillance of pasteurized milk was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies who have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis. Publication in *RHD* follows 3 to 4 months after sample collection because of time required for shipment, processing, radiochemical analysis for strontium, data compilation, and publication procedures.

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all states and additional points when indicated by widely varying conditions of the milk supply or the need to cover large population groups. Each sample is composited in proportion to the volume of milk sold by those plants supplying not less than 90 percent of a city's milk supply. Prior to September 15, 1961, this composite sample was taken from one day's sales per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling schedule has been increased in frequency. During July 1962, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation

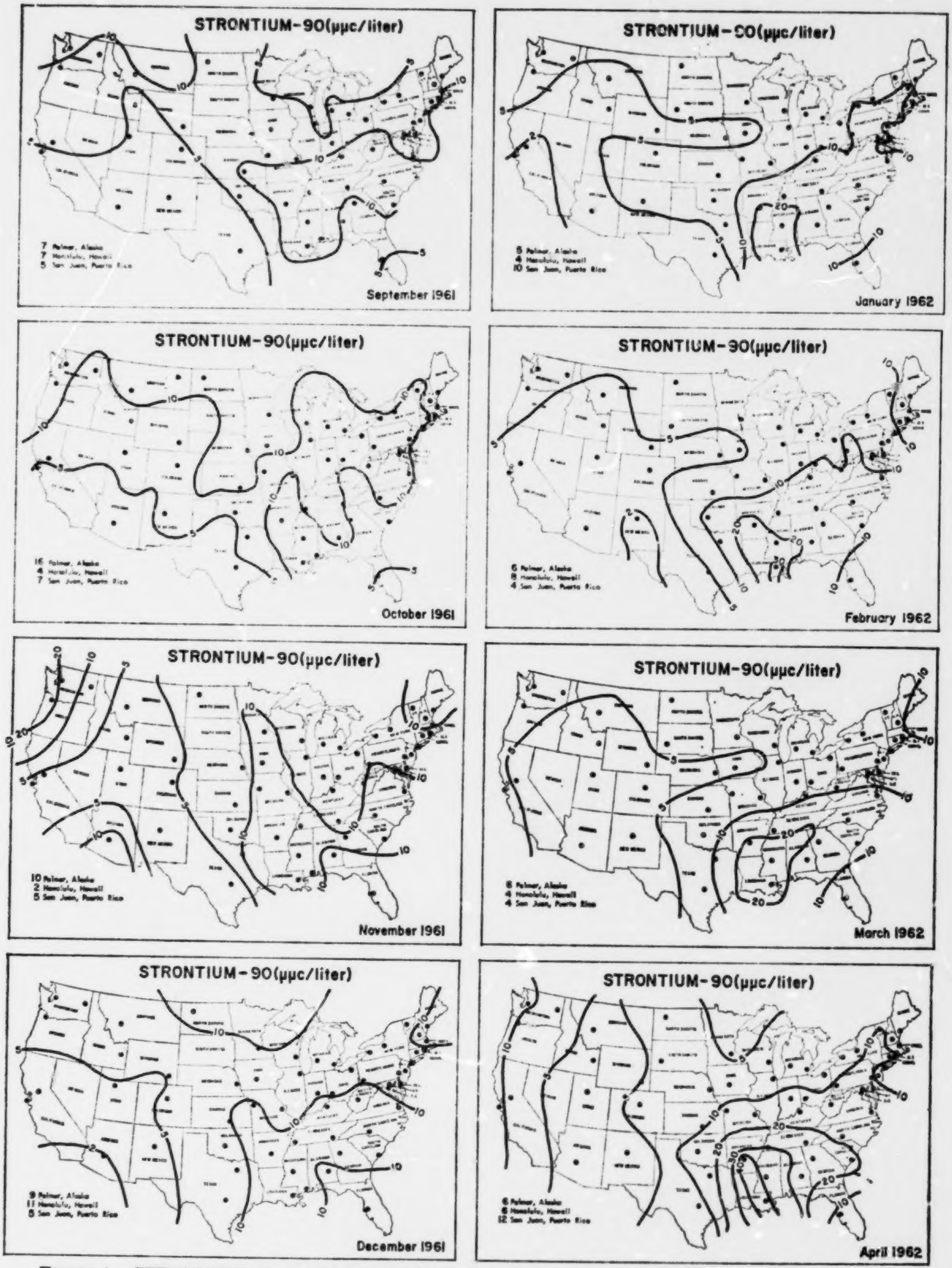
STRONTIUM-90(μμc/liter)
7 Palmer, Alaska
7 Honolulu, Hawaii
5 San Juan, Puerto Rico
September 1961
STRONTIUM-90(μμc/liter)
5 Palmer, Alaska
4 Honolulu, Hawaii
10 San Juan, Puerto Rico
January 1962
STRONTIUM-90(μμc/liter)
16 Palmer, Alaska
4 Honolulu, Hawaii
7 San Juan, Puerto Rico
October 1961
STRONTIUM-90(μμc/liter)
6 Palmer, Alaska
8 Honolulu, Hawaii
4 San Juan, Puerto Rico
February 1962
STRONTIUM-90(μμc/liter)
10 Palmer, Alaska
2 Honolulu, Hawaii
5 San Juan, Puerto Rico
November 1961
STRONTIUM-90(μμc/liter)
8 Palmer, Alaska
4 Honolulu, Hawaii
4 San Juan, Puerto Rico
March 1962
STRONTIUM-90(μμc/liter)
9 Palmer, Alaska
11 Honolulu, Hawaii
5 San Juan, Puerto Rico
December 1961
STRONTIUM-90(μμc/liter)
6 Palmer, Alaska
6 Honolulu, Hawaii
12 San Juan, Puerto Rico
April 1962

FIGURE 1.—STRONTIUM-90 CONCENTRATION CONTOURS AND MILK SAMPLING STATIONS

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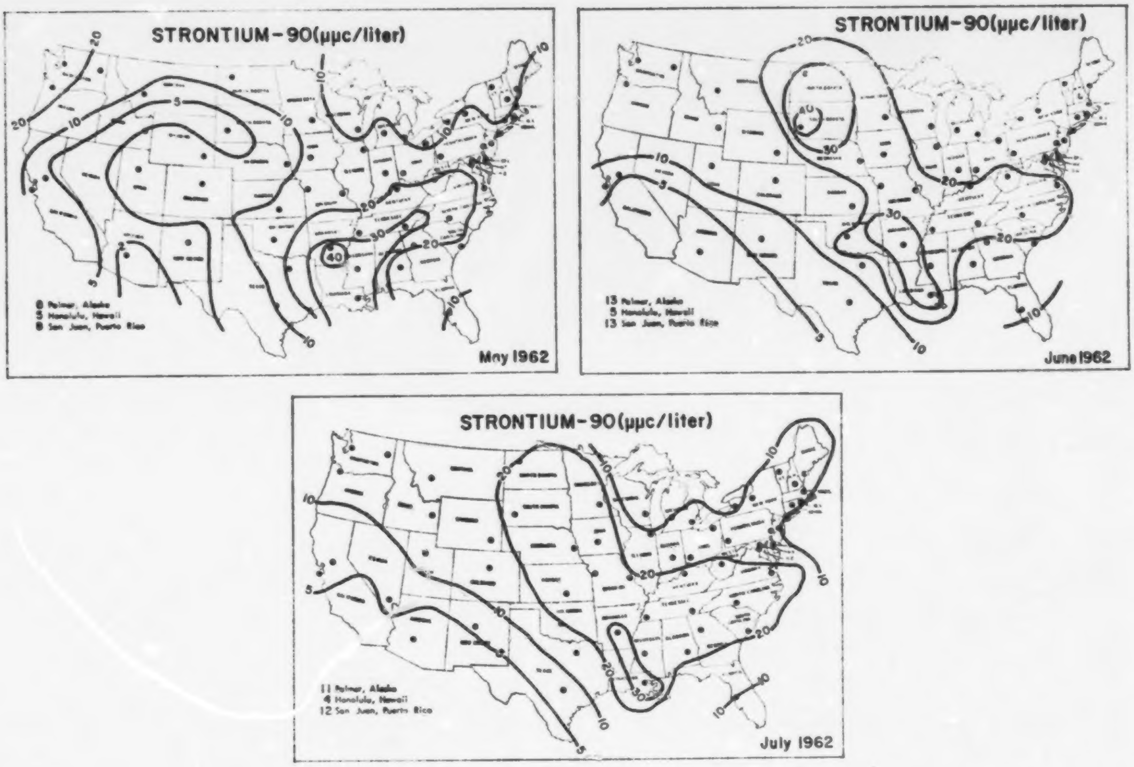
STRONTIUM-90(μμc/liter)
8 Palmer, Alaska
5 Honolulu, Hawaii
8 San Juan, Puerto Rico
May 1962
STRONTIUM-90(μμc/liter)
13 Palmer, Alaska
5 Honolulu, Hawaii
13 San Juan, Puerto Rico
June 1962
STRONTIUM-90(μμc/liter)
11 Palmer, Alaska
4 Honolulu, Hawaii
12 San Juan, Puerto Rico
July 1962

FIGURE 1.—STRONTIUM-90 CONCENTRATION CONTOURS AND MILK SAMPLING STATIONS—Continued

to observe unusual patterns or concentrations which may require immediate attention and adjustment to the Pasteurized Milk Network sampling schedule. Further atmospheric nuclear testing may require an immediate reevaluation and readjustment of the sampling frequency and analytical schedule for this program.

Iodine-131, cesium-137, and barium-140 are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 are determined following radiochemical separation. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for July 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Strontium-90 Geographical Distribution

Figure 1 geographically displays the average strontium-90 concentrations in pasteurized milk from September 1961 through July 1962. These plots are based on concentrations in pasteurized milk representing milk sold in the Network station locations in 62 cities distributed throughout the United States. Intervening milk sheds for smaller cities or the effect on intra- and interstate milk distribution are not taken into consideration. This permits the use of concentration contours to present these data geographically. The highest monthly average concentration of strontium-90 in July occurred at New Orleans, Louisiana.

In previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from selected cities in the moni-

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, JULY 1962

[Average radioactivity concentrations in μμc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Last Sr^{90} profile in RHD
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	
Ala:	Montgomery	1.20	1.19	105	40	19	14	10	10	55	40	20	20	Oct. 62
Alaska:	Palmer	1.08	1.02	35	30	9	11	10	10	20	50	<10	<10	Nov. 62
Ariz:	Phoenix	1.09	1.06	15	15	3	2	<10	20	10	20	<10	30	Sep. 62
Ark:	Little Rock	1.17	1.19	225	95	37	33	20	10	95	70	40	20	Nov. 62
Calif:	Sacramento	1.09	1.08	30	10	5	4	10	20	15	25	<10	20	Aug. 62
	San Francisco	1.10	1.12	55	10	9	4	<10	30	15	25	10	30	Oct. 62
Colo:	Denver	1.16	1.10	30	80	8	18	<10	50	10	85	<10	20	Aug. 62
Conn:	Hartford	1.19	1.15	15	20	11	12	<10	10	35	80	<10	<10	Aug. 62
Del:	Wilmington	1.20	1.11	50	20	15	12	10	10	50	70	<10	<10	Sep. 62
D. C:	Washington	1.15	1.15	50	55	15	16	<10	<10	40	65	10	20	Oct. 62
Fla:	Tampa	1.21	1.21	25	20	10	10	<10	<10	105	140	<10	10	Sep. 62
Ga:	Atlanta	1.20	1.24	120	50	22	22	<10	20	80	65	20	20	Oct. 62
Hawaii:	Honolulu	1.08	1.02	30	15	5	4	<10	10	25	30	<10	<10	Nov. 62
Idaho.	Idaho Falls	1.09	1.07	25	65	7	13	10	50	20	100	10	20	Sep. 62
Ill:	Chicago	1.16	1.14	35	20	11	12	20	40	30	60	10	<10	Oct. 62
Ind:	Indianapolis	1.20	1.12	50	30	15	14	20	20	40	50	20	<10	Aug. 62
Iowa:	Des Moines	1.08	1.05	95	95	15	15	60	50	25	40	20	20	Sept. 62
Kans:	Wichita	1.08	1.12	65	85	12	15	120	60	20	40	20	20	Nov. 62
Ky:	Louisville	1.17	1.15	115	90	21	22	20	<10	40	45	20	20	Sep. 62
La:	New Orleans	1.23	1.21	215	100	37	36	<10	10	135	95	30	20	Nov. 62
Maine:	Portland	1.22	1.18	20	20	12	18	<10	10	50	120	<10	<10	Sep. 62
Md:	Baltimore	1.17	1.13	45	45	15	16	10	<10	50	55	10	10	Sept. 62
Mass:	Boston	1.16	1.14	20	30	13	18	<10	<10	50	130	<10	<10	Oct. 62
Mich:	Detroit	1.17	1.12	25	20	11	14	<10	20	30	70	<10	<10	Aug. 62
	Grand Rapids	1.23	1.18	20	20	10	10	<10	20	30	60	<10	<10	Sep. 62
Minn:	Minneapolis	1.08	1.08	60	110	13	25	50	30	30	95	10	30	Oct. 62
Miss:	Jackson	1.26	1.26	220	80	33	26	<10	20	85	60	30	20	Aug. 62
Mo:	Kansas City	1.09	1.03	130	110	18	15	150	60	30	40	40	20	Aug. 62
	St. Louis	1.08	1.03	85	90	16	19	30	40	30	50	10	40	Nov. 62
Mont:	Helena	1.08	1.11	45	130	10	16	20	30	25	85	10	40	Nov. 62
Nebr:	Omaha	1.13	1.08	65	115	13	16	40	70	20	50	10	30	Sep. 62
Nev:	Las Vegas	[a]	1.04	[a]	25	[a]	6	[a]	60	[a]	40	[a]	10	[a]
N. H:	Manchester	1.15	1.11	15	25	10	17	<10	10	60	160	<10	<10	Sep. 62
N. J:	Trenton	1.13	1.11	25	20	10	10	<10	10	30	60	<10	<10	Aug. 62
N. Mex:	Albuquerque	1.09	1.06	15	25	4	7	10	40	<5	35	10	20	Nov. 62
N. Y:	Buffalo	1.16	1.10	20	20	10	14	<10	20	40	70	<10	<10	Aug. 62
	New York	1.13	1.08	20	35	12	15	10	10	40	80	<10	<10	Oct. 62
	Syracuse	1.17	1.12	20	20	10	9	20	20	25	55	<10	<10	Nov. 62
N. C:	Charlotte	1.22	1.21	95	70	22	25	<10	<10	55	60	20	20	Nov. 62
N. D.:	Minot	1.10	1.06	60	145	16	25	20	50	30	85	<10	20	Sep. 62
Ohio:	Cincinnati	1.18	1.12	65	30	17	14	20	30	30	50	20	<10	Aug. 62
	Cleveland	1.15	1.09	35	25	11	13	<10	10	30	55	<10	<10	Nov. 62
Okla:	Oklahoma City	1.15	1.14	115	80	21	20	60	20	60	60	30	20	Oct. 62
Ore:	Portland	1.13	1.06	95	30	17	14	10	30	55	65	10	20	Aug. 62
Pa:	Philadelphia	1.16	1.12	35	20	13	14	<10	20	45	70	<10	<10	Nov. 62
	Pittsburgh	1.17	1.09	35	30	14	15	10	20	45	90	<10	<10	Nov. 62
P. R:	San Juan	1.13	1.19	75	40	11	12	20	<10	55	40	20	20	Nov. 62
R. I:	Providence	1.19	1.13	20	20	12	13	10	<10	45	85	<10	<10	Sep. 62
S. C:	Charleston	1.20	1.20	95	55	21	22	<10	20	75	65	20	10	Aug. 62
S. D:	Rapid City	1.09	0.99	70	115	17	20	<10	50	30	30	10	40	Oct. 62
Tenn:	Chattanooga	1.24	1.23	200	75	28	26	10	<10	90	65	30	20	Oct. 62
	Memphis	1.21	1.20	160	85	27	23	<10	10	40	30	30	20	Sept. 62
Tex:	Austin	1.17	1.17	35	20	8	8	<10	<10	25	30	<10	<10	Oct. 62
	Dallas	1.18	1.18	115	50	18	18	20	<10	50	40	20	10	Aug. 62
Utah:	Salt Lake City	1.11	1.06	25	70	8	12	<10	580	30	130	<10	60	Nov. 62
Vt:	Burlington	1.13	1.14	15	25	10	13	<10	10	30	90	<10	<10	Aug. 62
Va:	Norfolk	1.19	1.18	70	75	17	26	<10	<10	55	95	10	10	Aug. 62
Wash:	Seattle	1.12	1.05	80	50	18	14	<10	50	55	100	<10	30	Oct. 62
	Spokane	1.15	1.11	60	60	14	15	120	80	35	70	<10	20	Aug. 62
W. Va:	Charleston	1.17	1.13	80	110	18	24	20	10	35	60	20	20	Oct. 62
Wis:	Milwaukee	1.20	1.08	15	20	8	8	10	30	15	60	<10	<10	Sep. 62
Wyo:	Laramie	1.10	1.07	30	130	8	16	20	370	25	140	10	100	Sep. 62
Network average		1.15	1.12	70	53	14.4	15.6	19	38	42	67	12	17	

[a] The Las Vegas station entered the network in July 1962.

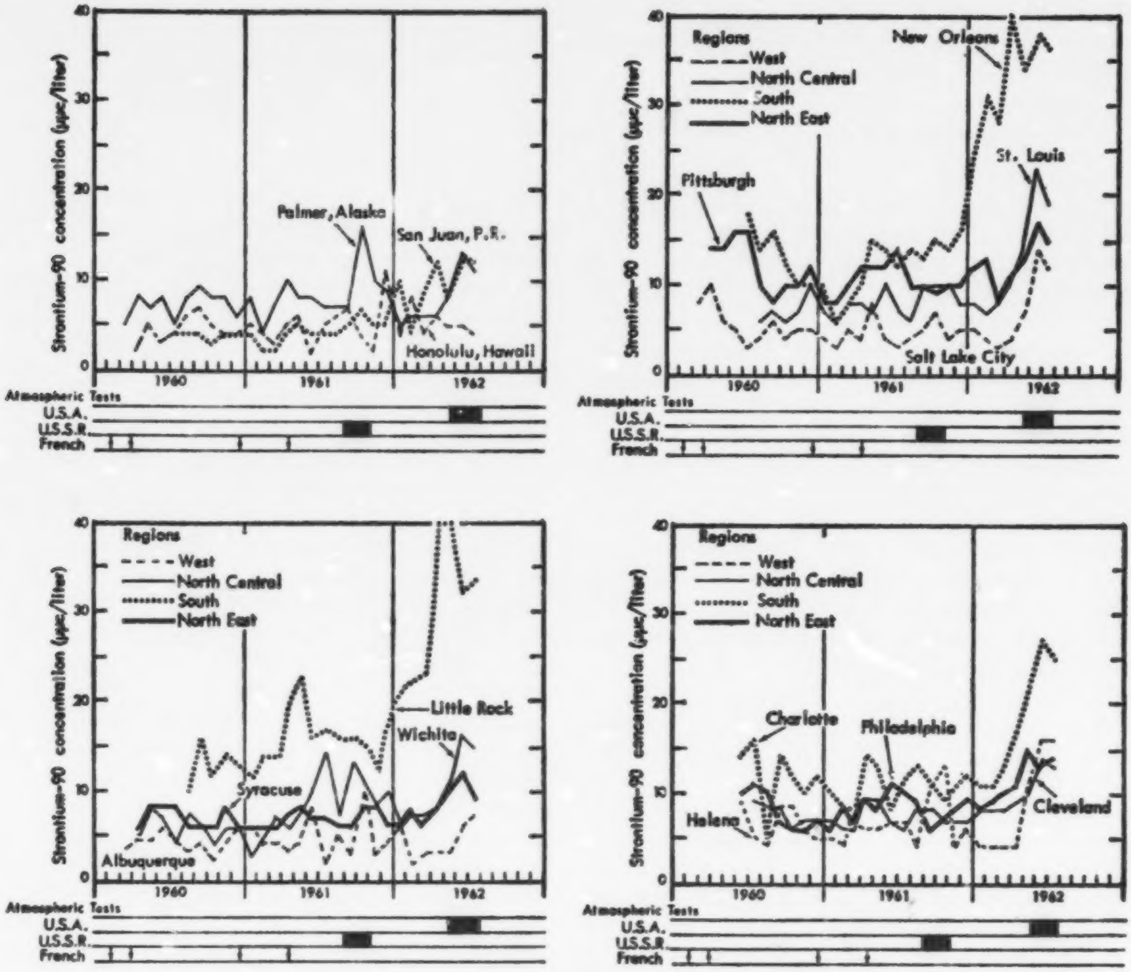
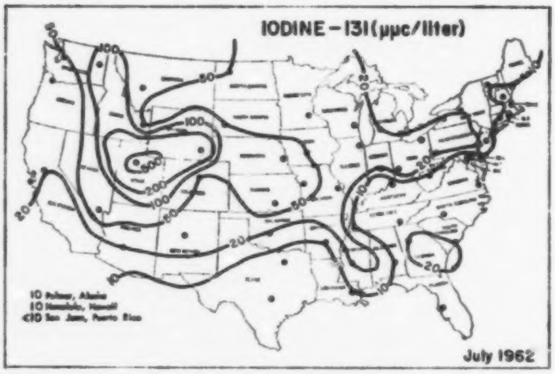


FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

toring program were published. Profiles for an additional 15 cities are presented in figure 2. These graphs show the strontium-90 concentrations in milk from selected cities in the USDA marketing regions of the United States.

Iodine-131 Geographical Distribution

Figure 3 presents geographically the July 1962 average iodine-131 concentrations. Monthly averages of iodine-131 from September 1961 through June 1962 are shown on similar maps in the October 1962 issue of *RHD*. The highest July average iodine-131 concentration (580 μμc/l) occurred at Salt Lake City, Utah.



IODINE-131 (μμc/liter)
500
200
100
50
20
10
10 Palmer, Alaska
10 Honolulu, Hawaii
<10 San Juan, Puerto Rico
July 1962

FIG. 3.–IODINE-131 CONCENTRATION CONTOURS AND PASTEURIZED MILK SAMPLING STATIONS

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TWELVE-MONTH SUM OF DAILY RADIONUCLIDE CONTENT OF ONE LITER OF PASTEURIZED MILK

September 1961–August 1962

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The ranges are based on radiation doses considered acceptable for lifetime exposure from normal peacetime operations. The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures (*1, 2*).

To facilitate comparison of the concentration of certain radionuclides in milk with the Radiation Protection Guides, tables 2 and 3 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine–131 and strontium–90 respectively. The tables are based on the same data which are used for computing the Pasteurized Milk Network monthly averages. They present index values which are the sum of the daily amounts of these two radionuclides in one liter of milk for a 12–month period.

The tables show 12–month index values for each of the Network's 62 sampling locations. The first column in both tables shows the monthly radionuclide averages. The second column consists of 12–month index values. Due to the longer time required for strontium–90 analysis, the 12–month index values for this radionuclide are for the year beginning one month earlier than the iodine–131 values. The following two columns in the tables are used to compute the net change as the yearly index values are advanced by one month. The last columns show this 12–month index value.

The data in tables 2 and 3 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and a daily average for the month is assigned, and (c) the monthly radionuclide index value, is determined by multiplying the daily average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. This procedure minimizes the effect of any one day's sample results on the sample average.

It is desirable to have a standard quantity of milk to use in the development of index values for the different radionuclides and for a number of reasons. In the case of strontium, 1 liter is a suitable quantity as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. In the case of iodine–131, the critical age group is the young infant. Available information suggests that the average daily milk consumption of infants in the 6–18 month group is not more than 1 liter. Thus, the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159–65 (May 1962.)

(*2*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

Sampling locations index values		August 1962 Iodine-131 averages (μμc/liter)	Iodine-131 index values (μμc day/liter)[a]			
			Aug. 1961–July 1962	Aug. 1961	July 29–Aug. 25, 1962	Sep. 1961–Aug. 1962[f]
Ala:	Montgomery	<10	4,510	0	140	4,650
Alaska:	Palmer	10	23,730	0	280	24,010
Ariz:	Phoenix	<10	8,320	0	140	8,460
Ark:	Little Rock	10	14,580	0	280	14,860
Calif:	Sacramento	20	4,200	0	560	4,760
	San Francisco	<10	4,450	0	140	4,590
Colo:	Denver	30	8,830	0	840	9,670
Conn:	Hartford	<10	6,090	0	140	6,230
Del:	Wilmington	10	7,340	0	280	7,620
D. C:	Washington	<10	5,500	0	140	5,640
Fla:	Tampa	<10	5,490	0	140	5,630
Ga:	Atlanta	20	8,630	0	560	9,190
Hawaii:	Honolulu	10	4,160	0	280	4,440
Idaho:	Idaho Falls	30	15,630	0	840	16,470
Ill:	Chicago	20	14,100	0	560	14,660
Ind:	Indianapolis	<10	8,870	0	140	9,010
Iowa:	Des Moines	20	32,190	0	560	32,750
Kans:	Wichita	20	26,180	0	560	26,740
Ky:	Louisville	10	10,510	0	280	10,790
La:	New Orleans	20	9,280	0	560	9,840
Maine:	Portland	20	6,750	0	560	7,310
Md:	Baltimore	<10	6,960	0	140	7,100
Mass:	Boston	10	10,670	0	280	10,950
Mich:	Detroit	20	17,290	0	560	17,850
	Grand Rapids	20	9,100	0	560	9,660
Minn:	Minneapolis	<10	31,920	0	140	32,060
Miss:	Jackson	10	12,290	0	280	12,570
Mo:	Kansas City	30	32,810	0	840	33,650
	St. Louis	20	18,500	0	560	19,060
Mont:	Helena	20	17,390	0	560	17,950
Nebr:	Omaha	40	26,600	0	1,120	27,720
Nev:	Las Vegas	20	[b]1,680	0	560	[c]2,240
N. H:	Manchester	20	8,660	0	560	9,220
N. J:	Trenton	<10	7,750	0	140	7,890
N. Mex:	Albuquerque	20	6,860	0	560	7,420
N. Y:	Buffalo	<10	8,510	0	140	8,650
	New York	<10	10,450	0	140	10,590
	Syracuse	<10	12,020	0	140	12,160
N. C:	Charlotte	<10	4,430	0	140	4,570
N. D:	Minot	20	9,430	0	560	9,990
Ohio:	Cincinnati	20	11,820	0	560	12,380
	Cleveland	<10	9,130	0	140	9,270
Okla:	Oklahoma City	10	18,850	0	280	19,130
Ore:	Portland	10	11,700	0	280	11,980
Pa:	Philadelphia	10	7,890	0	280	8,170
	Pittsburgh	10	8,900	0	280	9,180
P. R:	San Juan	<10	4,750	0	140	4,890
R. I:	Providence	<10	8,190	0	140	8,330
S. C:	Charleston	10	6,950	0	280	7,230
S. D:	Rapid City	20	[d]2,840	0	560	[e]3,400
Tenn:	Chattanooga	<10	8,490	0	140	8,630
	Memphis	<10	14,770	0	140	14,910
Tex:	Austin	<10	5,010	0	140	5,150
	Dallas	20	7,500	0	560	8,060
Utah:	Salt Lake City	330	27,800	0	9,240	37,040
Vt:	Burlington	<10	8,960	0	140	9,100
Va:	Norfolk	<10	7,460	0	140	7,600
Wash:	Seattle	20	10,720	0	560	11,280
	Spokane	20	25,030	0	560	25,590
W. Va:	Charleston	<10	6,560	0	140	6,700
Wis:	Milwaukee	10	14,130	0	280	14,410
Wyo:	Laramie	160	16,310	0	4,480	20,790

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual I^{131} intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index (μμc day/liter) × milk consumption factor (liter/day/person) = 12 month I^{131} intake (μμc/person)

[b] The index value is for July 1962.

[c] The index value is for two months, July 1962–August 1962.

[d] The index value is for the seven-month period, January 1962–July 1962.

[e] The index value is for the eight-month period, January 1962–August 1962.

[f] Index values for stations for which September 1961 data were not available include an estimate for that month based on the October 1961 values.

TABLE 3.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		July 1962 Strontium-90 averages (μμc/liter)	Strontium-90 index values (μμc day/liter)[a]			
			July 1961–June 1962	July 1961	July 1, 1962–July 29, 1962	August 1961—July 1962
Ala:	Montgomery[b]	14	3,349	—	392	3,751
Alaska:	Palmer	11	3,079	217	308	3,170
Ariz:	Phoenix	2	1,397	93	56	1,360
Ark:	Little Rock	33	8,233	527	924	8,630
Calif:	Sacramento	4	1,681	155	112	1,638
	San Francisco	4	1,899	124	112	1,887
Colo:	Denver	18	2,284	155	504	2,633
Conn:	Hartford	12	3,352	310	336	3,378
Del:	Wilmington	12	4,137	248	336	4,225
D. C:	Washington	16	3,596	248	448	3,796
Fla:	Tampa	10	2,584	186	280	2,678
Ga:	Atlanta	22	5,101	310	616	5,407
Hawaii:	Honolulu	4	2,031	155	112	1,988
Idaho:	Idaho Falls	13	2,148	279	364	2,233
Ill:	Chicago	12	2,698	186	336	2,848
Ind:	Indianapolis	14	3,524	186	392	3,730
Iowa:	Des Moines	15	3,576	217	420	3,779
Kans:	Wichita	15	3,627	434	420	3,613
Ky:	Louisville	22	4,751	279	616	5,088
La:	New Orleans	36	8,506	372	1,008	9,142
Maine:	Portland	18	3,959	341	504	4,122
Md:	Baltimore	16	3,819	372	448	3,895
Mass:	Boston	18	4,039	372	504	4,171
Mich:	Detroit	14	2,730	217	392	2,905
	Grand Rapids	10	2,900	186	280	2,994
Minn:	Minneapolis	25	3,766	310	700	4,156
Miss:	Jackson	26	7,477	310	728	7,895
Mo:	Kansas City	15	4,035	341	420	4,114
	St. Louis	19	3,730	217	532	4,045
Mont:	Helena	16	2,690	217	448	2,921
Nebr:	Omaha	16	3,620	279	448	3,789
Nev:	Las Vegas[c]	6	—	—	168	168
N. H:	Manchester	17	3,814	310	476	3,980
N. J:	Trenton	10	3,232	248	280	3,264
N. Mex:	Albuquerque	7	1,532	62	196	1,666
N. Y:	Buffalo	14	3,054	248	392	3,198
	New York	15	3,525	310	420	3,635
	Syracuse	9	2,808	217	252	2,843
N. C:	Charlotte	25	5,183	372	700	5,511
N. D:	Minot[d]	25	3,468	—	700	4,168
Ohio:	Cincinnati	14	4,110	310	392	4,192
	Cleveland	13	3,060	186	364	3,238
Okla:	Oklahoma City	20	4,083	186	560	4,457
Ore:	Portland	14	4,629	372	392	4,649
Pa:	Philadelphia	14	3,506	310	392	3,588
	Pittsburgh	15	4,168	434	420	4,154
P. R:	San Juan	12	2,632	124	336	2,844
R. I:	Providence	13	3,786	372	364	3,778
S. C:	Charleston	22	5,228	310	616	5,534
S. D:	Rapid City[e]	20	2,276	—	560	2,836
Tenn:	Chattanooga	26	6,115	341	728	6,502
	Memphis	23	5,946	310	644	6,280
Tex:	Austin	8	1,865	62	224	2,027
	Dallas	18	3,948	248	504	4,204
Utah:	Salt Lake City	12	2,009	93	336	2,252
Vt:	Burlington	13	3,117	310	364	3,171
Va:	Norfolk	26	4,335	310	728	4,753
Wash:	Seattle	14	4,390	434	392	4,348
	Spokane	15	3,197	248	420	3,369
W. Va:	Charleston	24	4,400	310	672	4,762
Wis:	Milwaukee	8	2,358	155	224	2,427
Wyo:	Laramie	16	2,301	248	448	2,501

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month Sr^{90} index (μμc day/liter) × milk consumption factor (liter/day/person) = 12 month Sr^{90} intake (μμc/person)

[b] The station began operation in October 1961.
[c] The station began operation in July 1962.
[d] The station began operation in September 1961.
[e] The station began operation in January 1962.

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INDIANA MILK MONITORING NETWORK

October 1961–August 1962

Bureau of Environmental Sanitation
Indiana State Board of Health

Following the resumption of atmospheric testing of nuclear devices by the U.S.S.R. in September 1961, the Indiana State Board of Health initiated a program of milk sampling for radiological analyses. Indiana was geographically divided into five major milksheds with one large dairy within each milkshed being selected as a sampling station (see figure 4).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium-lanthanum–140, strontium–89, and strontium–90. Analyses for iodine–131, cesium–137, and barium-lanthanum–140 are conducted on a weekly basis except when iodine–131 results exceed 100 μμc/l at which time frequency of sampling is increased. Samples which are analyzed for strontium–89 and strontium–90 are composited weekly and analyzed monthly.

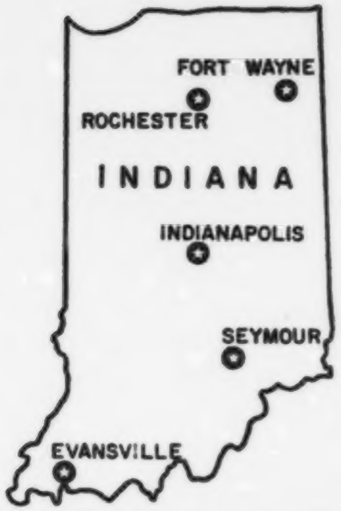

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

The trichloroacetic acid analytical procedure is used for strontium–89 and strontium–90 analyses. In March 1962, a 512–channel pulse height analyzer and shielded 4" x 4" NaI crystal were installed in the radiological laboratory for the gamma scintillation analysis of iodine–131, cesium–137, and barium-lanthanum–140. Prior to that time a protein precipitation procedure followed by well-scintillation counting was used as a screening method for iodine–131.

The monthly averages of the data obtained for the individual sampling stations and the state averages are reported in table 3.

TABLE 3.—INDIANA MILK MONITORING NETWORK, OCTOBER 1961–AUGUST 1962
[Concentrations in μμc/liter]

Date	Fort Wayne					Rochester					Evansville				
	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$	Sr^{89}	Sr^{90}
Oct 61				100	9				40	3				70	8
Nov 61				40	2				10	3				30	2
Dec 61									20	8				<10	9
Jan 62				<10	8				<10	8				<10	8
Feb 62				<10	10				<10	9				<10	3
Mar 62	<10	20	<10	<10	6	<10	20	<10	<10	10	<10	15	<10	<10	5
Apr 62	<10	15	<10	10	5	<10	20	<10	10	4	<10	20	<10	25	10
May 62	20	45	<10	90	15	80	60	10	95	19	20	35	<10	55	14
Jun 62	20	55	<10	55	9	30	80	<10			50	55	<10	120	10
Jul 62	20	60	<10	105	12	20	65	<10	80	14	20	45	<10	55	14
Aug 62	20	40	<10			10	45	<10			20	30	<10		

Date	Seymour					Indianapolis					State averages*				
	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$	Sr^{89}	Sr^{90}
Oct 61				40	10				20	4				50	7
Nov 61				10	3				20	3				20	3
Dec 61				20	9				40	4				30	8
Jan 62				30	5				<10	5				10	7
Feb 62				<10	6				<10	6				<10	7
Mar 62	<10	20	<10	<10	4				<10	5	<10	20	<10	<10	6
Apr 62	<10	25	<10	35	8	<10	20	<10	<10	7	<10	20	<10	15	7
May 62	10	40	<10	65	17	20	45	<10	80	17	30	45	<10	75	16
Jun 62	30	90	<10	330	29	50	70	<10			40	70	<10	170	16
Jul 62	20	60	<10	125	22	20	50	<10	75	17	20	55	<10	90	16
Aug 62	20	45	<10			<10	35	<10			20	40	<10		

* Numerical average, not weighted for milk production.

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
May 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network, operated in cooperation with State and local agencies, commenced operations in October 1957 (*1*). By the end of May 1962, 113 stations located on major waterways used for public water supply, propagation of fish and wildlife, and recreational, industrial, and agricultural purposes were submitting water samples for analyses of plankton population, organic chemicals, stream flow data, chemical, biological, and physical quality, and radioactivity (*2, 3*). Samples are taken weekly, monthly, or continuously depending on the type of analysis and the degree of water quality.

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment procedures (*4*). Naturally-occurring radioactive substances in the environment are the source of essentially all the alpha activity, while contamination from man-made sources is the major contributor of beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples according to established procedures (*5, 6*).

For the first two years, alpha determinations were reported generally on composites of more than one weekly sample. As of January 1960, the policy was established that analyses were to be done weekly for the first operating year of each new station. At some stations on the Colorado and Animas Rivers, determinations were done on weekly samples or semimonthly on 2- or 3-week composites. The remainder of the stations were scheduled so that each station made one gross alpha determination per month. Beginning with November 1961, gross alpha determinations have been made on one sample from each station each month, unless there is evidence of alpha activity in excess of background levels. In the latter instance, an alpha determination has been made on a weekly or biweekly basis, depending on the particular station.

For the first two years of the network operations, beta determinations were made on weekly samples. Since January 1959, a portion of each sample from all stations in the network has been composited into a 3-month station

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[(Average concentrations in $\mu\mu c$/liter)]

Station	Quarter ending December 31, 1961	May 1962					
	Total Strontium-90	Beta activity			Alpha activity		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	—	2	6	8	—	—	—
Animas River: Cedar Hill, N. Mex	0.9	28	15	43	3	1	4
Apalachicola River: Chattahoochie, Fla.	—	3	8	11	0	0	0
Arkansas River:							
Coolidge, Kansas	1.0	90	118	208	5	37	42
Ponca City, Okla.	—	27	58	85	3	5	8
Big Horn River: Hardin, Mont.	—	74	34	108	12	5	17
Big Sioux River: Sioux Falls, So. Dak.	1.2	29	70	99	1	2	3
Chattahoochie River:							
Atlanta, Ga.	0.3	3	8	11	0	0	0
Columbus, Ga.	—	1	11	12	—	—	—
Clear Water River: East Lewiston, Idaho	0.3	6	9	15	0	0	0
Colorado River:							
Loma, Colo.	—	33	24	57	1	3	4
Page, Ariz.	—	9	22	31	1	2	3
Boulder City, Nev.	1.8	10	36	46	0	7	7
Parker Dam, Calif.	—	6	27	33	0	5	5
Yuma, Ariz.	—	44	84	128	0	3	3
Columbia River:							
Northport, Wash.	—	1	5	6	0	0	0
Wenatchee, Wash.	0.7	2	4	6	—	—	—
Pasco, Wash.	—	32	122	154	—	—	—
McNary Dam, Oreg.	—	11	69	80	0	1	1
Bonneville, Oreg.	—	29	66	95	—	—	—
Clatskanie, Oreg.	—	24	34	58	—	—	—
Connecticut River: Wilder, Vt.	3.7	9	18	27	0	0	0
Cumberland River: Clarksville, Tenn.	0.9	—	—	—	—	—	—
Delaware River:							
Martins Creek, Pa.	—	4	13	17	0	0	0
Trenton, New Jersey	0.7	3	13	16	1	<1	1
Philadelphia, Pa.	—	5	12	17	0	0	0
Escambia River: Century, Fla.	—	24	18	42	0	0	0
Great Lakes:							
Duluth, Minn.	0.1	2	6	8	0	0	0
Sault Ste. Marie, Mich.	—	7	7	14	—	—	—
Milwaukee, Wis.	—	5	7	12	0	0	0
Gary, Ind.	0.1	4	10	14	0	12	12
Port Huron, Mich.	—	4	8	12	0	0	0
Detroit, Mich.	—	5	9	14	0	0	0
Buffalo, N. Y.	0.8	14	14	28	0	0	0
Hudson River: Poughkeepsie, N. Y.	2.5	0	13	13	0	1	1
Illinois River:							
Peoria, Ill.	—	15	36	51	—	—	—
Grafton, Ill.	—	6	23	29	0	2	2
Kanawha River: Winfield Dam, W. Va.	—	4	12	16	0	1	1
Klamath River: Keno, Oreg.	1.2	6	22	28	—	—	—
Little Miami River: Cincinnati, Ohio	0.6	51	40	91	0	0	0
Mississippi River:							
St. Paul, Minn.	—	17	42	59	0	2	2
Dubuque, Iowa	—	42	38	80	0	1	1
Burlington, Iowa	—	24	27	51	0	1	1
E. St. Louis, Ill.	—	28	34	62	—	—	—
Cape Giraudeau, Mo.	—	52	32	84	1	2	3
W. Memphis, Ark.	—	36	24	60	3	1	4
Delta, La.	—	24	30	54	2	1	3
New Orleans, La.	—	20	25	45	—	—	—
Vicksburg, Miss.	—	67	27	94	1	<1	1
Missouri River:							
Williston, N. Dak.	—	100	31	131	—	—	—
Bismarck, N. Dak.	—	14	23	37	—	—	—
Yankton, S. Dak.	2.5	7	38	45	—	—	—
Omaha, Nebr.	—	114	36	150	39	1	40
St. Joseph, Mo.	—	43	39	82	—	—	—
Kansas City, Kan.	—	43	22	65	—	—	—
St. Louis, Mo.	2.1	26	39	65	—	—	—
Monongahela River: Pittsburgh, Pa.	—	2	22	24	0	0	0
North Platte River: Henry, Nebr.	1.3	50	67	117	2	23	25
Ohio River:							
East Liverpool, Ohio	—	11	16	27	1	1	2
Huntington, W. Va.	—	2	14	16	0	0	0
Cincinnati, Ohio	—	29	18	47	2	0	2
Louisville, Ky.	—	26	46	72	0	1	1
Evansville, Ind.	—	5	14	19	0	1	1
Cairo, Ill.	—	14	18	32	1	0	1
Ouachita River: Bastrop, La.	0.7	28	43	71	<1	0	<1
Pend Oreille River: Albeni Fall Dam, Idaho	—	2	3	5	0	0	0
Platte River: Plattsmouth, Nebr.	—	40	34	74	4	9	13
Potomac River:							
Williamsport, Md.	0.9	5	18	23	—	—	—
Great Falls, Md.	—	2	10	12	0	0	0
Rainy River:							
Baudette, Minn.	—	13	52	65	0	0	0
International Fls, Minn.	—	7	28	35	0	0	0
Red River, North: Grand Forks, N. Dak.	—	14	67	81	—	—	—

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

Station	Quarter ending December 31, 1961	May 1962					
	Strontium-90	Beta activity			Alpha activity		
		Total Suspended	Dissolved	Total	Suspended	Dissolved	Total
Red River, South:							
Denison, Tex.	—	25	56	81	1	3	4
Index, Ark.	—	77	44	121	1	4	5
Alexandria, La.	—	42	20	71	11	0	11
Rio Grande River:							
Alamosa, Colo.	—	21	22	43	1	0	1
El Paso, Tex.	—	46	34	80	2	2	4
Laredo, Tex.	—	94	32	126	0	0	0
Brownsville, Tex.	—	14	21	35	—	—	—
Roanoke River: John H. Kerr Resr. & Dam, Va.	—	14	15	29	<1	0	<1
Sabine River: Ruliff, Tex.	—	28	8	36	1	1	2
St. Lawrence River: Massena, N. Y.	1.6	5	7	12	0	2	2
San Juan River: Shiprock, N. Mex.	—	30	15	45	8	1	9
Savannah River:							
North Augusta, S. C.	—	20	18	38	0	0	0
Port Wentworth, Ga.	—	9	18	27	0	0	0
Schuylkill River: Philadelphia, Penn.	—	18	14	32	—	—	—
Shenandoah River: Berryville, Va.	0.2	26	16	42	1	<1	1
Snake River							
Payette, Idaho	—	12	26	38	1	3	4
Wawawai, Wash.	—	8	14	22	—	—	—
Ice Harbor Dam, Wash.	—	2	10	12	0	0	0
South Platte River: Julesburg, Colo.	—	286	126	412	18	21	39
Spokane River: Post Falls, Idaho	—	8	8	16	0	0	0
Susquehanna River:							
Sayre, Pa.	—	4	7	11	0	0	0
Conowingo, Md.	—	2	12	14	0	0	0
Tennessee River:							
Lenoir City, Tenn.	—	2	12	14	0	0	0
Chattanooga, Tenn.	0.5	0	30	30	0	0	0
Bridgeport, Ala.	—	4	38	42	0	0	0
Pickwick Landing, Tenn.	—	9	27	36	1	0	1
Tombigbee River: Columbus, Miss.	0.2	7	18	25	<1	<1	<1
Truckee River: Farad, Calif.	—	5	7	12	0	0	0
Verdigris River: Nowata, Okla.	—	11	36	47	0	2	2
Wabash River: New Harmony, Ind.	—	155	30	185	10	2	12
Yakima River: Richland, Wash.	—	6	12	18	<1	<1	1

sample for measurement of strontium-90 (*7*). Beginning January 1960, analyses were performed weekly for the first operating year of each new station. Weekly analyses were to be continued indefinitely for all stations which may be affected by waste discharges from nuclear installations. Where stations have been operated for more than 1 year, semimonthly determinations on composites of 2 or 3 weekly samples were performed when beta activity was found to be above background. Monthly determinations on composites of all samples received from a station during the month were conducted on samples from streams where beta activity was at background levels. Since September 1961, gross beta determinations have been made on all samples collected.

The data reported in table 1 represent the average of all data reported for the periods indicated. The reported strontium-90 data are the results of determinations on 3-month composite samples for the quarter ending in the month shown.

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Gross Beta Activity of Water Supplies Around the Nevada Test Site
December 1961–June 1962

U. S. Atomic Energy Commission

By contract with the Atomic Energy Commission, the Public Health Service has conducted an offsite monitoring program around the Nevada Test Site (NTS) since 1955. This program includes sampling of air, water, and milk. Milk data for the period July 1961–June 1962 were presented in *RHD*, October 1962.

Figure 1 shows the relationship of the water sampling locations to the Nevada Test Site. All locations shown are not sampled each month but on a rotation basis so that in any given yearly period the necessary information is available to adequately describe the environmental radiation situation in the offsite area. During an operational period, intensive monitoring occurs in the areas affected. These data are published in special reports by the Atomic Energy Commission.

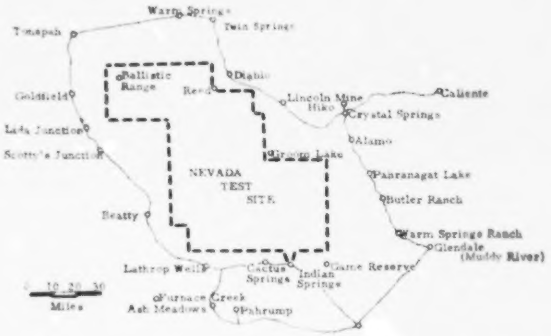
Warm Springs
Twin Springs
Tonopah
Ballistic Range
Reed
Diablo
Goldfield
Lincoln Mine
Hiko
Caliente
Crystal Springs
Lida Junction
Alamo
Scotty's Junction
Groom Lake
NEVADA TEST SITE
Pahranagat Lake
Butler Ranch
Beatty
Warm Springs Ranch
Glendale (Muddy River)
Lathrop Wells
Cactus Springs
Indian Springs
Game Reserve
0 10 20 30
Miles
Furnace Creek
Ash Meadows
Pahrump

FIGURE 1.—WATER SAMPLING LOCATIONS AROUND THE NEVADA TEST SITE

Table 1 summarizes the gross beta measurements in water supplies located in the NTS offsite area for December 1961 through June 1962. The minimum detectable concentration is about 10 μμc/liter. Unless labeled otherwise in table 1, the water supplies are wells or capped springs.

Previous coverage in *Radiological Health Data*:

Period	Issue
November–December 1959	*April 1960*
January–April 1960	*September 1960*
May–June 1960	*November 1960*
July–August 1960	*January 1961*
September–December 1960	*May 1961*
January–February 1961	*June 1961*
March–June 1961	*November 1961*
July–October 1961	*June 1962*
November 1961	*April 1962*

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TABLE 1.—GROSS BETA ACTIVITY OF WATERS SUPPLIES IN OFFSITE AREAS OF THE NEVADA TEST SITE, DECEMBER 1961–JUNE 1962

Location (see fig. 1)	Source	Population served	Gross beta concentration ($\mu\mu c$/liter)						
			December	[b]January	February	March	April	May	June
Alamo	2 wells, 50–67 ft. deep	175	[a]—	—	19	—	26	—	30
Ash Meadows	Spring, 25 ft. deep	8	—	—	12	14	—	<10	17
	Pond		—	—	36	20	—	17	17
Ballistic Range	Drilled well	10–15	10	—	—	16	13	98	—
Beatty	Spring	550	16	—	<10	19	—	<10	<15
Butler Ranch	Flowing spring	1	—	—	23	—	13	—	10
Cactus Springs	Well	10+	<10	—	26	—	26	—	<10
Caliente	Springs	10–12	—	—	14	—	34	—	10
	Creek		—	—	67	—	45	—	28
Crystal Springs	Free flowing spring	0	—	—	15	—	—	—	13
Diablo	Well	State highway station	17	—	51	15	45	—	30
Furnace Creek			—	—	—	24	—	—	13
Game Reserve	Drilled well, 400 ft. deep	20	—	—	<10	—	<10	—	<10
	Pond		—	—	<10	—	35	—	20
Glendale	Tap		—	—	—	—	—	—	20
	River		—	—	15	—	23	—	36
Goldfield	Spring	200	12	—	<10	<10	35	19	—
Groom Lake	Well		—	—	13	—	—	—	<10
Hiko			—	—	—	—	—	—	22
Indian Springs	Drilled well, 600 ft. deep	250	<10	—	—	—	—	—	<10
Lake Mead	Surface		<10	—	32	—	26	—	14
Las Vegas	13 wells, 650–1,250 ft. deep and Lake Mead	40,000	<10	—	<10	—	10	—	<10
Lathrop Wells	3 wells, 600 ft. deep	15	<10	—	<10	17	—	49	<10
Lida Junction	Drilled well, 125 ft. deep	2–10	25	—	17	25	28	61	—
Lincoln Mine	2 driven wells	3	—	—	22	16	<10	—	—
Pahranagat Lake	Surface (Not used for domestic purposes)		—	—	81	—	68	—	53
Pahrump	Driven well, 75 ft. deep	10–50	—	—	<10	<10	—	19	10
Scotty's Junction			—	—	—	15	37	13	—
Tonopah	2 drilled wells, 60 ft. deep	1,500	13	—	14	<10	21	54	—
Twin Springs	Pond		205	—	140	273	244	—	50
Warm Springs Ranch	Flowing spring from earth fault	Public park with swimming pool	—	—	32	—	17	—	19
Warm Springs	Well	10	35	- -	45	43	20	—	—
	Pond		117	—	110	75	96	—	—

[a] Dash indicates no sample.
[b] No data for January because of construction work in laboratory.

SECTION V.—OTHER DATA

Survey of Dental X-Ray Machines in San Juan, Puerto Rico[1]

University of Puerto Rico School of Dentistry, and
Division of Sanitation, Puerto Rico Department of Health

During June and July of 1961, the School of Dentistry of the University of Puerto Rico and the Department of Health of the Commonwealth of Puerto Rico jointly sponsored a survey of X-ray machines in dental offices in the San Juan metropolitan area. The survey sample covered 100 dental offices, or 25% of the total in Puerto Rico.

The basic objectives of the project were: to determine the exposure to radiation of patients and occupational personnel; to determine how each machine compared with current standard criteria for X-ray protection; and to assist in bringing each machine up to current standards so that the radiation exposure of operator and patient could be reduced to the lowest practical levels.

Among the survey's principal findings are the following:

Beam Diameters (Collimation)

Beam diameters were measured with the aid of a flourescent screen at the tip of the pointer cone. It was found that 47.5% of the machines surveyed had beam diameters larger than the recommended 2.75 inches (*1*, *2*), which was the median beam diameter. Only 5% had beam diameters larger than 4 inches. A reduction in diameter from 4 to 2.75 inches will reduce the area exposed by one-half. Doses to the lens of the eye and thyroid, as well as volume irradiated and scatter radiation will be also reduced. The distribution of beam diameters is shown in figure 1.

Beam Filtration

The total beam filtration was found by totaling the inherent filtration read from published

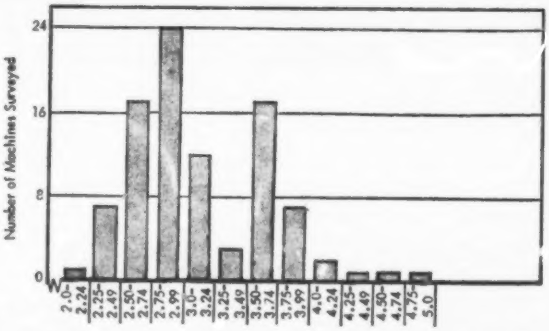

FIGURE 1.—DISTRIBUTION OF BEAM DIAMETERS IN INCHES

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[1] Abstracted from: *A Study of the Radiation Hazards Existing in the Dental Offices of San Juan, Puerto Rico,* by E. W. Robinson, J. V. Arenas, V. M. Dutail, and F. Alvarez, a report developed by the Division of Sanitation, Puerto Rico Department of Health, in cooperation with the Puerto Rico School of Dentistry.

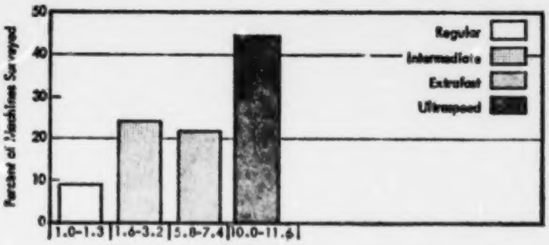

FIGURE 2.—DISTRIBUTION OF RELATIVE FILM SPEEDS

tables and the added filtration directly measured. In some cases total filtration was determined by employing a modification of the method developed by Hale (*3*), using two 25r Victoreen ionization chambers. Of the X-ray machines surveyed, 81.8% had total aluminum equivalent filtration less than the recommended 2 mm (*1*).

Machine Output Rate

The output rate of each machine was measured with a 25r ionization chamber placed at the end of the pointer cone and the machine set at the exposure factors used by the dentist. The average output rate was found to be 2.12 r/second. Four percent of the machines had outputs greater than 5 r/second. On an experimental basis, a dental X-ray machine was set up to give the average values for the tube kilovoltage (65 kvp), tube current (10 ma), and total equivalent aluminum filtration (1.25 mm) found in the survey. It was found that the machine output (2.1 r/second) was in close agreement with the average machine output. When 2 mm total aluminum equivalent filtration was used, the output was found to be 1.36 r/second. While it was found that the additional filtration would make it necessary to increase the exposure time slightly, the net result would be a significant reduction in the dose delivered to the patient.

Relative Film Speed

The average relative film speed, based on a value of 1.0 assigned to the slowest film (4), was found to be 6.65. This higher value would be classified as an extrafast film, i.e., within the range 5.8 to 7.4; 33% of the dentists surveyed used films which are classified as being slower than extrafast, while 44% used films classified as being faster than extrafast. The ultraspeed film is in the relative speed rang 10 to 11.6. An alternative to the relative film speed method is that reported by the Counci on Dental Research (*5*). Figure 2 shows the distribution of the relative film speeds found.

Films per Week

The average number of films taken per week per dental office was found to be 26.5. Fifty-five percent of the dentists reported taking 25 or less films per week. The low occupational exposures found in the survey are attributed to this relatively low workload.

Face Dose per Film

Facial skin doses per film ranged from 0.08 to 14.4 r, with an average dose of 2.65 r Eighty-nine per cent of the dentists surveyed gave their patients an average facial skin dose of over 0.5 r per film; eleven per cent gave their patients a facial skin dose equal to or less than 0.5 r per film. It is possible to limit the average facial skin dose to less than 0.5 r by using ultraspeed film, 2 mm total aluminum equivalent filtration, and good technique. The distribution of facial skin doses found in the survey is shown in figure 3.

Film Development Techniques

In addition to such factors as kilovoltage setting, filtration, film speed, roentgen output, and exposure time, film development techniques are also important in influencing the facial skin dose delivered per film. The survey originally contemplated evaluating film development techniques from information obtained regarding usual development time, type of developer, temperature of the developer, and how often the developer was changed. This information proved to be inaccurate and misleading, however, because most dentists did not know their developer temperature and did not use a de-

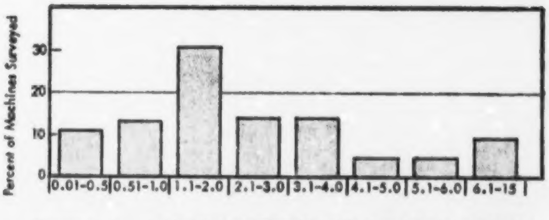

FIGURE 3.—DISTRIBUTION OF FACIAL SKIN DOSE PER FILM IN ROENTGENS

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velopment timer. Film development techniques were finally evaluated by determining what the approximate facial skin dose should be for the same conditions of filtration, kilovoltage, and film speed, assuming optimal film development. If it was determined that the facial skin dose was well above this approximation, then it was assumed that the film was underdeveloped to compensate for overexposure of the film. Generally, the survey found that underdevelopment of films was the rule rather than the exception.

Operator Radiation Exposure

Approximations of the total weekly radiation exposure to the X-ray machine operator were also made. The scattered radiation at the position normally occupied by the operator was measured with a dose-rate meter for left bitewing, right bitewing, and anterior periapical exposures, using a wood block as a "phantom," or scattering object to simulate the human head. The position the operator usually occupied and the distance from the tube head for these exposures were noted.

These approximated weekly exposures were found to be low; 83% of the operators surveyed received 10 mr or less per week. Only 2% of the operators exceeded the recommended occupational exposure of 100 mr per week (*1*). A summary of the approximate operator radiation exposures is contained in figure 4.

It was found that some operators were not standing at least 6 feet from the tube head and out of the primary beam. Of the operators surveyed, 46% always stood less than 6 feet from the tube head; 38% stood between 3 and 6 feet from the tube head, and 8% never stood more than 3 feet from the tube head. However, 54% always stood at least 6 feet from the tube head. In many cases the timer cord was not long enough to permit the operator to stand far enough from the tube head.

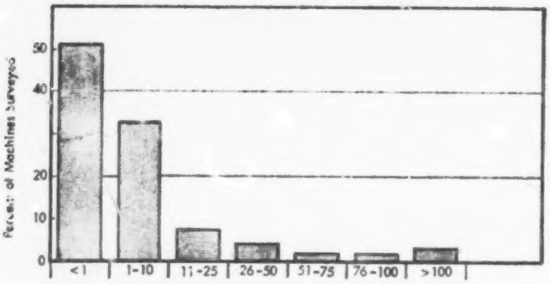

FIGURE 4.—DISTRIBUTION OF APPROXIMATE WEEKLY DENTAL X-RAY MACHINE OPERATOR RADIATION EXPOSURE IN MILLIROENTGENS

Another factor contributing to operator exposure is leakage from the tube housing. It was found that the tubes in the newer X-ray machine models are adequately shielded. The older machines surveyed did not meet present standards (*1*).

Conclusions

The survey disclosed that most dental X-ray machines do not meet the standards for radiation protection but can be brought up to standards (*1, 2*) by simple and inexpensive means. The radiation exposure of X-ray machine operators was generally low, due in large part to the small number of films taken per week. This exposure can be reduced by adopting simple precautions and by making improvements in technique. It was concluded that operator exposure could be kept below 100 mr per week and patient exposure reduced, even with a substantial number of films taken each week, if: (1) the beam was properly collimated, (2) adequate filtration was used, (3) a combination of ultrafast film, proper exposure, and optimal development were employed, and (4) the operator would stand at a distance of at least 6 feet from the tube and well out of line from the primary beam. Added protection can be gained by shielding.

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External Gamma Activity

RADIATION SURVEILLANCE NETWORK
August 1962

Division of Radiological Health,
Public Health Service

Daily measurements of external gamma radiation are made at stations of the Radiation Surveillance Network to assure detection of any substantial deviations from normal background levels reported in recent years. Portable Geiger-Mueller survey instruments are used to obtain measurements at three feet above the ground surface. August 1962 data given in table 1 are characteristic of individual station observations which define the range of normal background values.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, AUGUST 1962

Station location		Average (mr/hr)
Alaska:	Adak	0.01
	Anchorage	0.01
	Attu	0.01
	Fairbanks	0.01
	Juneau	0.01
	Kodiak	0.01
	Nome	0.01
	Point Barrow Island	0.01
	St. Paul Island	0.04
Ariz:	Phoenix	0.01
Ark:	Little Rock	0.01
Calif:	Berkeley	0.01
"	Los Angeles	0.02
Colo:	Denver	0.02
Conn:	Hartford	0.01
Del:	Dover	0.01
D.C:	Washington	0.04
Fla:	Jacksonville	0.01
	Miami	0.01
Ga:	Atlanta	[a] —
Guam:	Agana	0.01
Hawaii:	Honolulu	0.01
Idaho:	Boise	0.02
Ill:	Springfield	0.01
Ind:	Indianapolis	0.01
Iowa:	Iowa City	0.01
Kans:	Topeka	0.02
Ky:	Frankfort	0.01
La:	New Orleans	0.02
Maine:	Augusta	0.02
"	Presque Isle	0.02
Md:	Baltimore	0.02
	Rockville	—
Mass:	Lawrence	0.02
	Winchester	0.02
Mich:	Lansing	0.02
Minn:	Minneapolis	0.01
Miss:	Jackson	0.01
	Pascagoula	0.01
Mo:	Jefferson City	0.01
Mont:	Helena	0.01
Nebr:	Lincoln	0.01
Nev:	Las Vegas	0.01
N.H:	Concord	—
N.J:	Trenton	0.02
N.Mex:	Santa Fe	0.05
N.Y:	Albany	0.02
	Buffalo	0.01
	New York	—
N.C:	Gastonia	0.02
N.Dak:	Bismark	0.01
Ohio:	Columbus	0.01
	Painesville	0.01
Okla:	Oklahoma City	0.02
	Ponca City	0.02
Ore:	Portland	0.02
Pa:	Harrisburg	0.02
P.R:	San Juan	0.01
R.I:	Providence	0.02
S.C:	Columbia	0.02
S.Dak:	Pierre	0.02
Tenn:	Nashville	0.01
Tex:	Austin	0.01
	El Paso	0.03
Utah:	Salt Lake City	0.02
Vt:	Barre	0.02
Va:	Richmond	0.01
W.Va:	Charleston	—
Wash:	Seattle	0.02
Wis:	Madison	0.01
Wyo:	Cheyenne	0.02

[a] Dash indicates no data received.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

FEED MATERIALS PRODUCTION FACILITIES

Malinckrodt Chemical Works
Weldon Spring, Missouri

First Half 1962

Environmental monitoring results at the Feed Materials Production Facilities (FMPF), Weldon Spring, Missouri, are expressed in special uranium microcuries since uranium ore concentrates constitute the primary feed material.

The units of concentration in this report are based on a curie of recently extracted uranium as defined in the NCRP Report No. 22 (National Bureau of Standards "Handbook 69").

Process chemical wastes and other process residues are premanently retained in storage facilities located at both the plant site and two storage sites located adjacent to the Lambert-St. Louis Municipal Airport and at a quarry near the Missouri River (see figure 1). The plant process sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit continual measurement of any re-

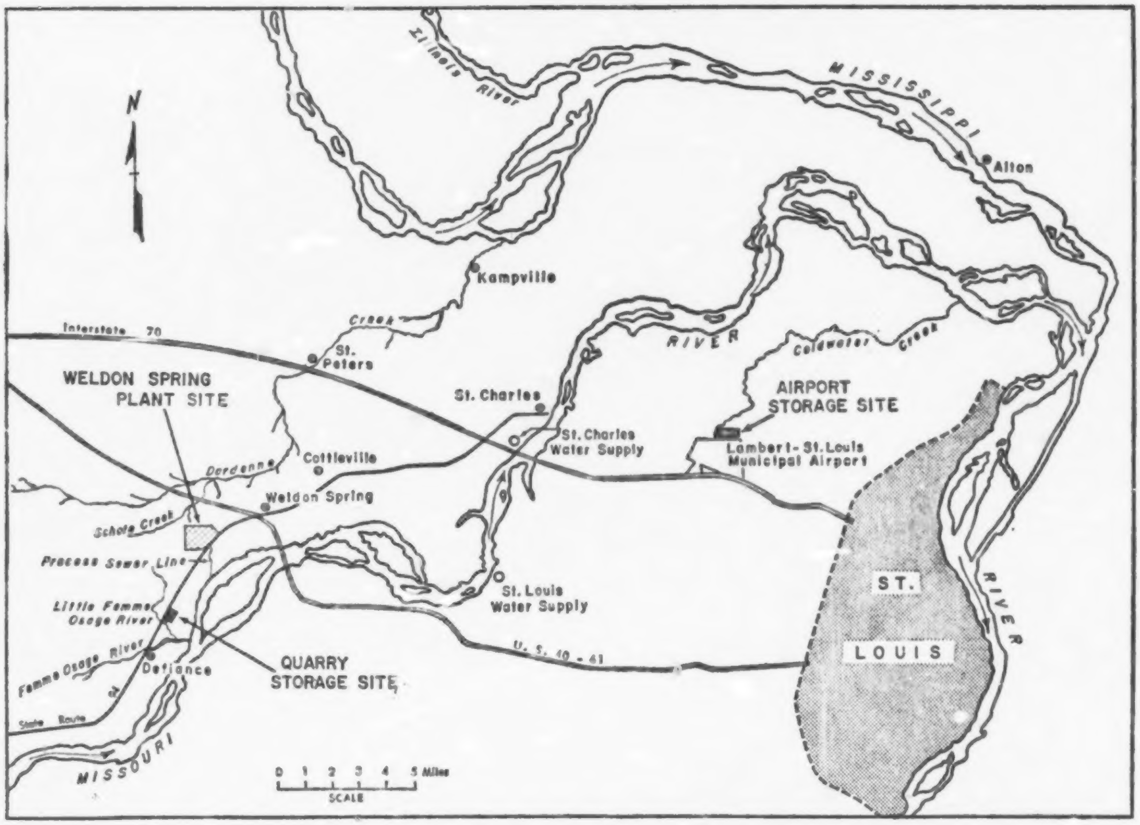
N
Illinois River
MISSISSIPPI
Alton
Kampville
Creek
Interstate 70
St. Peters
WELDON SPRING PLANT SITE
St. Charles
St. Charles Water Supply
RIVER
Coldwater Creek
AIRPORT STORAGE SITE
Lambert-St. Louis Municipal Airport
Dardenne
Cottleville
Weldon Spring
Schote Creek
Process Sewer Line
Little Femme Osage River
Femme Osage River
Defiance
QUARRY STORAGE SITE
St. Louis Water Supply
U. S. 40 - 61
ST. LOUIS
RIVER
State Route
MISSOURI
0 1 2 3 4 5 Miles
SCALE

FIGURE 1.—LOCATION OF FEED MATERIALS PRODUCTION FACILITIES, WELDON SPRING, MO.

TABLE 1.—URANIUM CONCENTRATIONS IN AIR

[Average concentrations in $\mu\mu c/m^3$]

On-site sample location			First half 1962	
Site	Position	Direction from plant	Number of samples	Uranium concentration*
Plant	Fence line	Northeast	6	0.067
	Roof	East	6	0.114
	Fence line	North	6	0.126
	Roof	Northwest	6	0.092
	Open area	Southwest	6	0.012
	Roof	Southeast	6	0.273
	Not reported	South-southwest	4	0.039
	Not reported	West	3	0.035
	Not reported	North-northwest	6	0.089
	Average			0.096
Quarry	Edge of quarry	South	5	0.012
Airport	4 locations	North, south, east, west		0.018

* Environmental MPC for natural uranium in air is 2 $\mu\mu c/m^3$ (from NCRP-NBS Handbook 69).

lease of uranium-bearing material into the river. Off-site water samples are also collected from lakes, creeks, and rivers located within the plant's watershed. Air samples are collected on-site along the plant perimeter fence and on building roofs.

Results of off-site air and water monitoring during the first half of 1962 indicate that the average release of uranium-bearing materials from FMPF was about one percent of the non-occupational area MPC for natural uranium.

Air Monitoring

Monthly air samples are collected on-site along the plant perimeter and on building roofs by 6 high volume sampling pumps. During 1961, monthly samples were also collected by 3 windmill sampling pumps located south-southwest, west, and north-northwest of the plant. Semiannual air samples are collected at 4 points on the perimeter of the airport storage site, and monthly air samples were begun during the first quarter of 1961 at the south edge of the quarry. First half 1962 air data are reported in table 2.

Water Monitoring

In addition to daily samples from the plant process sewer, monthly off-site water samples are collected from lakes and streams located within the plant's watershed, the Missouri River, and streams near the quarry at the points indicated in table 2.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and First Quarter 1960	*November 1960*
Third and Fourth Quarters 1960	*November 1961*
First and Second Quarters 1961	*November 1961*
Third and Fourth Quarters 1961	*July 1962*

TABLE 2.—URANIUM CONCENTRATIONS IN WATER

[Average concentrations in $\mu\mu c$/liter]

Sampling locations	Number of samples	Uranium concentration*
Process sewer, plant site	130	260
Missouri River sampling points:		
Defiance, upstream	6	1
Femme Osage junction, upstream	6	1
Process sewer outfall	6	280
U.S. Highway 40–61, north side	6	2
U.S. Highway 40–61, south side	6	1
St. Louis city water plant intake	6	2
St. Charles city water plant intake	6	2
Plant Offsite sampling points:		
Lake across from plant entrance	6	3
Lake, east of plant	6	2
Lake, north of plant	6	2
Lake, west of plant	6	1
Dardene Creek, upstream	6	1
Dardene Creek, Cottleville Bridge	6	3
Dardene Creek, St. Peters	9	3
Dardene Creek, Kampville	6	4
Schote Creek, upstream	6	1
Schote Creek, downstream	6	31
Plant surface drainage, west	6	400
Plant surface drainage, north	6	480
Quarry offsite sampling points:		
Little Femme Osage (LFO), ¼ mi. upstream	6	4
Branch, LFO, ¼ mi. upstream	6	1
LFO, at quarry discharge culvert	6	38
LFO, ¼ mi. downstream	6	2
LFO, 1-¼ mi. downstream	6	1
Airport offsite sampling points:		
Cold Water Creek, southwest corner of site	1	1
Cold Water Creek, northwest corner of site	1	1
Drainage ditch, north of site	1	140
After site pond discharge	1	4

* Environmental MPC for natural uranium in water is 20,000 $\mu\mu c$/liter.

Reported Nuclear Detonations
October 1962

During October 1962, nine U.S.S.R. and eleven U.S. detonations were announced by the Atomic Energy Commission. Two of the U.S.S.R. tests and two U.S. tests were described as "high altitude" detonations.

In preparation for the U.S. high altitude tests, the radius of the Johnston Island Test Area was extended on October 15 to 600 nautical miles at the surface, increasing gradually to 810 nautical miles at 40,000 feet and above. This change represents an increase of 130 nautical miles at the surface and 110 nautical miles at 40,000 feet. The coordinates of the center of the restricted area were shifted from 16° 45′ North, 169° 31′ West to 16° 15′ North, 169° 30′ West. Designed to accommodate tests of lower yield and altitude than the high altitude test of July 9, 1962, the size and shape of the area were established largely to guard against the possibility of retinal burns. The Atomic Energy Commission indicated that lower altitude tests would appear brighter but would minimize the possibility of contributing new radiation to the natural radiation belts above the earth.

Correction for September 1962 Summary: The yield range, given for the U.S.S.R. test of September 25, 1962, on page 423 of the October issue, should read "Multi-megaton" instead of "30 megatons." The Atomic Energy Commission has indicated that the yield for this test is slightly higher than the U.S.S.R. Multi-megaton test on September 19, 1962.

Test number	Location	Date (1962)	Yield range*	Type of test
REPORTED U.S.S.R. DETONATIONS				
50	Novaya Zemlya	October 7	Intermediate	Atmospheric
51	Semipalatinsk	14	Low	Atmospheric
52	Central Asia	22	Few hundred kilotons	High Altitude
53	Novaya Zemlya	22	Several megatons	Atmospheric
54	Novaya Zemlya	27	Intermediate	Atmospheric
55	Central Asia	28	Intermediate	High Altitude
56	Semipalatinsk	28	Low	Atmospheric
57	Novaya Zemlya	29	Intermediate	Atmospheric
58	Novaya Zemlya	30	Intermediate	Atmospheric
REPORTED U.S. DETONATIONS				
82	Johnston Island	2	Intermediate	Atmospheric
83	Nevada Test Site	5	Intermediate	Underground
84	Johnston Island	6	Low	Atmospheric
85	Nevada Test Site	12	Low	Underground
86	Johnston Island	18	Low megaton	Atmospheric
87	Nevada Test Site	19	Low	Underground
88	Johnston Island	20	Low	High Altitude
89	Johnston Island	26	Submegaton	High Altitude
90	Nevada Test Site	27	Low	Underground
91	Johnston Island	27	Intermediate	Atmospheric
92	Johnston Island	30	Megaton	Atmospheric

* Low yield range has been announced as less than 20 kilotons yield; intermediate yield is in the range of 20 kilotons up to 1 megaton; and low megaton yield is in the range from 1 to several megatons.

RADIOLOGICAL HEALTH DATA

VOLUME III, NUMBER 12
DECEMBER 1962

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

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ADVANCE REPORT

Reports during November 1962 to the Public Health Service Radiation Surveillance Center continued to indicate widespread occurrence of fresh fallout over the continental United States, Alaska, and Hawaii.

The Radiation Surveillance Network daily reported field estimates of gross beta radioactivity in air show levels rising over most of the United States the first part of November, reaching a peak on the 12th with generally higher levels in the West and South. Highest gross beta field estimates reported on the 12th were Denver, Colorado—170 $\mu\mu c/m^3$; Cheyenne, Wyoming—134 $\mu\mu c/m^3$; Santa Fe, New Mexico—101 $\mu\mu c/m^3$; and Salt Lake City, Utah—98 $\mu\mu c/m^3$. Air levels declined until November 23 when they again rose, reaching a peak in the Northwest States on the 25th and in the South Central and Southeastern States on the 26th with field estimates of 422 $\mu\mu c/m^3$ at Austin, Texas and 115 $\mu\mu c/m^3$ at New Orleans, which declined to 12 and 4 respectively by November 30th. During the latter part of the month, peak air readings for other areas of the country were: Berkeley, California—76 $\mu\mu c/m^3$ on the 25th; Miami, Florida—43 $\mu\mu c/m^3$ on the 27th; Portland, Oregon—42 $\mu\mu c/m^3$ on the 25th; and Concord, New Hampshire—43 $\mu\mu c/m^3$ on the 30th.

The general rise of radioactive air levels during the first two weeks of November was also reflected by a rise in gross beta radioactivity in precipitation. Most precipitation samples contained relatively young fission products (15–40 days as determined by the Way-Wigner method).

During November the Public Health Service's Pasteurized Milk Network monthly tabulation of the Network's 62 stations showed an average daily iodine–131 concentration of 70 $\mu\mu c$/liter. The October monthly average was 60 $\mu\mu c$/liter.

Fifty-three stations were above 20 $\mu\mu c$/liter compared to 46 stations during October. Of these 53 stations the following 11 stations had November monthly averages for iodine–131 of 100 $\mu\mu c$/liter or more:

Station	$\mu\mu c$/liter of milk	Station	$\mu\mu c$/liter of milk
Little Rock, Arkansas	100	Oklahoma City, Oklahoma	100
Wilmington, Delaware	140	Philadelphia, Pennsylvania	130
Des Moines, Iowa	120	Pittsburgh, Pennsylvania	170
Louisville, Kentucky	130	Memphis, Tennessee	100
Kansas City, Missouri	140	Milwaukee, Wisconsin	100
Cincinnati, Ohio	140		

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SECTION I.—AIR AND PRECIPITATION

Fission Product Beta Activity in Airborne Particulates and Precipitation

Measurements of gross beta activity of airborne particulates and precipitation are among the earliest and most sensitive indicators of increases of fission product activity in the environment. However, a direct evaluation of biological effects is not possible from these data alone.

Of the several networks or sampling programs making such measurements, the Radiation Surveillance Network and the 80th Meridian (West) Sampling Program are represented in the following reports.

RADIATION SURVEILLANCE NETWORK
September 1962

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network (RSN) was established in 1956 in cooperation with the Atomic Energy Commission primarily to provide a means of promptly monitoring increased levels of radioactivity in air and precipitation due to fallout from nuclear weapons tests. Prior to September 1961, the Network consisted of 45 stations. Following the September 1961 resumption of nuclear weapons testing by the U.S.S.R., the Network was expanded over a period of several months to 72 stations, whose locations are shown in figure 1.

Air

Daily 24-hour air samples are collected by a high volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field measurements with a portable survey meter enable the station operator to estimate the amount of beta activity in airborne particulates at the station 5 hours after collection by comparison with a known Sr^{90}-Y^{90} source. This 5-hour delay eliminates interference from naturally-occurring radon daughters. Each operator then reports his field estimate by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C., to provide a daily national report.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted after at least 3 days have elapsed from the end of the sampling period and is re-counted seven days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day interval, make possible the estimation of the age of fission products and extrapolation of the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2} = \text{constant}$).[1]

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[1] In this expression, A is the activity at time T after fission product formation. Units are arbitrary.

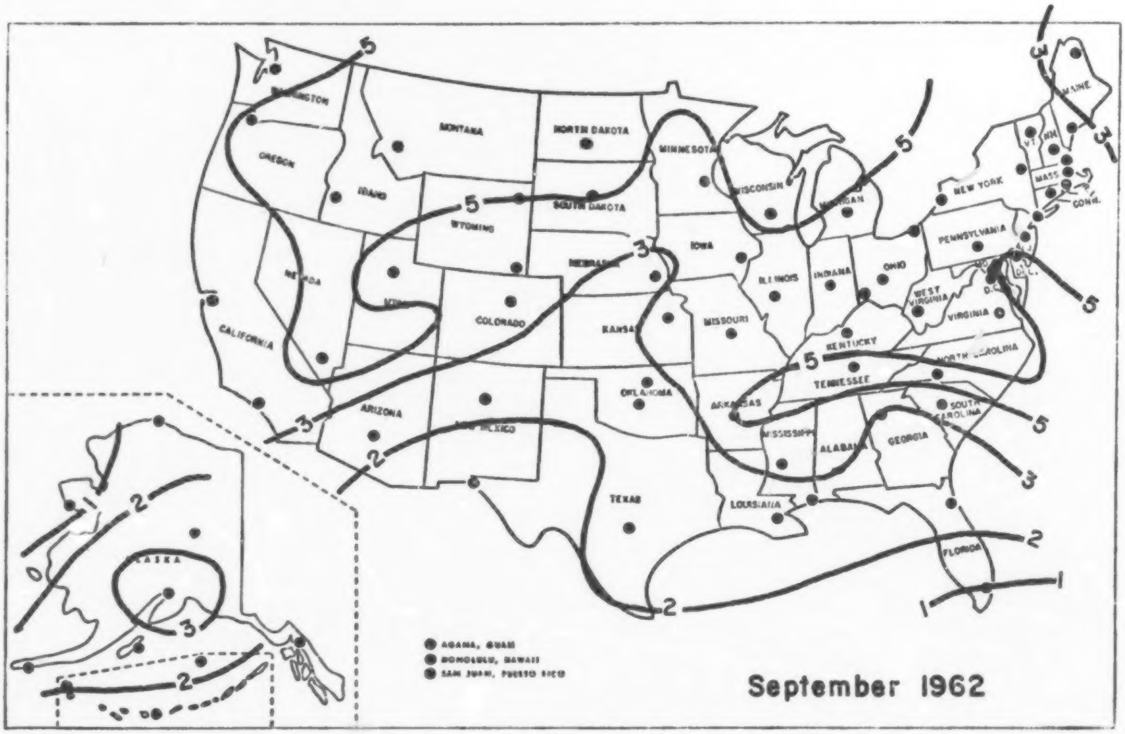
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VT.
NH
MAINE
MASS.
CONN.
D.C.
ALASKA
1
2
3
5
AGANA, GUAM
HONOLULU, HAWAII
SAN JUAN, PUERTO RICO
September 1962

Figure 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$) SEPTEMBER 1962

Although gross beta concentration is usually presented without reference to age, it is apparent that fission product activity is more adequately described when the age parameter is also given. Because of the difficulty in determining a meaningful monthly average age of fission products, such data have not yet been presented with RSN data in *RHD*.

The average fission-product beta concentrations in surface air during September 1962 as determined by laboratory analysis are tabulated in table 1 and presented by means of concentration contours in figure 1.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels having collection areas of 0.4 m^2. A 500–ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

The September 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and millimicrocuries per square meter ($m\mu c/m^2$) are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through September 1962 are shown in figure 2.

Table 1.—RADIOACTIVITY OF PARTICULATES IN AIR, RSN, SEPTEMBER 1962

Station location		Number samples	Maximum	Minimum	Average[a]
Alaska:	Adak	30	7.2	<0.10	1.9
	Anchorage	30	36	0.17	3.4
	Attu	30	5.5	0.30	2.0
	Fairbanks	20	26	0.30	2.9
	Juneau	20	8.8	0.46	2.4
	Kodiak	29	12	<0.10	2.8
	Nome	28	3.2	<0.10	0.6
	Point Barrow Isl	24	3.4	<0.10	1.2
	St. Paul Island	23	30	0.17	2.3
Ariz:	Phoenix	30	13	0.46	2.5
Ark:	Little Rock	30	19	0.18	5.0
Calif:	Berkeley	30	17	0.27	4.0
	Los Angeles	18	8.9	0.71	3.6
Colo:	Denver	29	20	0.75	4.9
Conn:	Hartford	27	14	0.33	3.5
Del:	Dover	17	23	0.40	5.9
D.C:	Washington	30	12	0.33	4.0
Fla:	Jacksonville	28	7.0	<0.10	2.3
	Miami	29	4.8	0.23	1.0
Ga:	Atlanta	29	8.9	0.35	3.0
Guam:	Agana	—	—	—	—
Hawaii:	Honolulu	30	2.7	0.33	1.2
Idaho:	Boise	29	18	1.8	5.6
Ill:	Springfield	30	16	0.58	4.3
Ind:	Indianapolis	29	16	1.0	3.9
Iowa:	Iowa City	30	12	0.33	4.3
Kans:	Topeka	30	15	0.17	3.4
Ky:	Frankfort	28	14	0.70	4.0
La:	New Orleans	30	11	0.32	2.3
Maine:	Augusta	30	14	0.28	3.5
	Presque Isle	30	9.3	<0.10	2.7
Md:	Baltimore	30	13	0.55	4.6
	Rockville	16	10	0.87	5.7
Mass:	Lawrence	30	11	<0.10	3.1
	Winchester	29	11	0.21	3.8
Mich:	Lansing	29	15	0.48	4.8
Minn:	Minneapolis	30	9.8	0.18	3.9
Miss:	Jackson	30	15	0.29	3.7
	Pascagoula	15	19	0.34	2.4
Mo:	Jefferson City	30	14	0.49	4.0
Mont:	Helena	30	39	0.53	8.3
Nebr:	Lincoln	14	7.1	0.20	2.1
Nev:	Las Vegas	16	28	0.59	6.7
N.H:	Concord	18	11	0.14	4.1
N.J:	Trenton	30	11	0.30	3.4
N. Mex:	Santa Fe	29	11	0.52	2.3
N. Y:	Albany	30	12	0.26	4.0
	Buffalo	30	14	0.36	4.4
	New York	15	7.6	0.45	3.9
N. C:	Gastonia	30	12	0.91	5.1
N. Dak:	Bismarck	29	21	0.21	6.2
Ohio:	Cincinnati	8	10	1.5	4.6
	Columbus	29	15	0.79	4.5
	Painesville	30	16	0.39	4.8
Okla:	Oklahoma City	28	9.2	0.23	2.6
	Ponca City	27	3.6	0.21	1.3
Ore:	Portland	30	19	0.57	5.9
Pa:	Harrisburg	27	11	0.18	3.7
P. R:	San Juan	27	1.6	0.22	0.8
R. I:	Providence	30	17	0.24	4.3
S. C:	Columbia	28	8.4	0.50	3.1
S. Dak:	Pierre	29	13	<0.10	5.0
Tenn:	Nashville	27	19	0.39	5.8
Tex:	Austin	30	10	0.28	2.6
	El Paso	29	3.1	0.18	1.1
Utah:	Salt Lake City	30	15	0.70	4.6
Vt:	Barre	30	10	0.66	4.0
Va:	Richmond	30	7.8	0.32	3.9
Wash:	Seattle	29	7.7	0.67	3.2
W. Va:	Charleston	30	9.5	0.81	3.9
Wis:	Madison	30	18	0.81	5.7
Wyo:	Cheyenne	30	12	0.33	4.3
Network Average					3.7

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

Table 2—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, SEPTEMBER 1962

Station location		Average concentration (μμc/liter)	Total deposition (mμc/m²)
Alaska:	Adak	2,300	6.9
	Anchorage	3,600	150
	Attu	*	*
	Fairbanks	*	*
	Juneau	2,800	650
	Kodiak	*	*
	Nome	*	*
	Point Barrow Isl	*	*
	St. Paul Island	*	*
Ariz:	Phoenix	*	*
Ark:	Little Rock	430	76
Calif:	Berkeley	*	*
	Los Angeles	*	*
Colo:	Denver	*	*
Conn:	Hartford	1,100	84
Del:	Dover	*	*
D. C:	Washington	2,300	160
Fla:	Jacksonville	470	51
	Miami	2,800	700
Ga:	Atlanta	400	22
Guam:	Agana	*	*
Hawaii:	Honolulu	*	*
Idaho:	Boise	1,100	11
Ill:	Springfield	530	14
Ind:	Indianapolis	520	36
Iowa:	Iowa City	420	3
Kans:	Topeka	500	61
Ky:	Frankfort	450	31
La:	New Orleans	380	40
Maine:	Augusta	740	69
	Presque Isle	750	54
Md:	Baltimore	840	8.4
	Rockville	*	*
Mass:	Lawrence	780	100
	Winchester	2,200	145
Mich:	Lansing	1,000	53
	Minneapolis	1,200	93
Miss:	Jackson	400	10
	Pascagoula	*	*
Mo:	Jefferson City	440	59
Mont:	Helena	3,800	52
Nebr:	Lincoln	430	21
Nev:	Las Vegas	*	*
N. H:	Concord	*	*
N. J:	Trenton	*	*
N. Mex:	Santa Fe	770	46
N. Y:	Albany	760	20
	Buffalo	1,100	36
	New York	*	*
N. C:	Gastonia	360	34
N. Dak:	Bismarck	2,000	49
Ohio	Cincinnati	*	*
	Columbus	1,100	150
	Painesville	1,700	270
Okla:	Oklahoma City	400	25
	Ponca City	570	48
Ore:	Portland	660	12
Pa:	Harrisburg	700	39
P. R:	San Juan	390	710
R. I:	Providence	1,100	81
S. C:	Columbia	460	48
S. Dak:	Pierre	1,300	13
Tenn:	Nashville	340	32
Tex:	Austin	440	35
	El Paso	410	32
Utah:	Salt Lake City	1,100	17
Vt:	Barre	840	68
Va:	Richmond	670	47
Wash:	Seattle	2,400	92
W. Va:	Charleston	650	40
Wis:	Madison	1,200	29
Wyo:	Cheyenne	1,100	36

* Indicates no evaporated sample received.

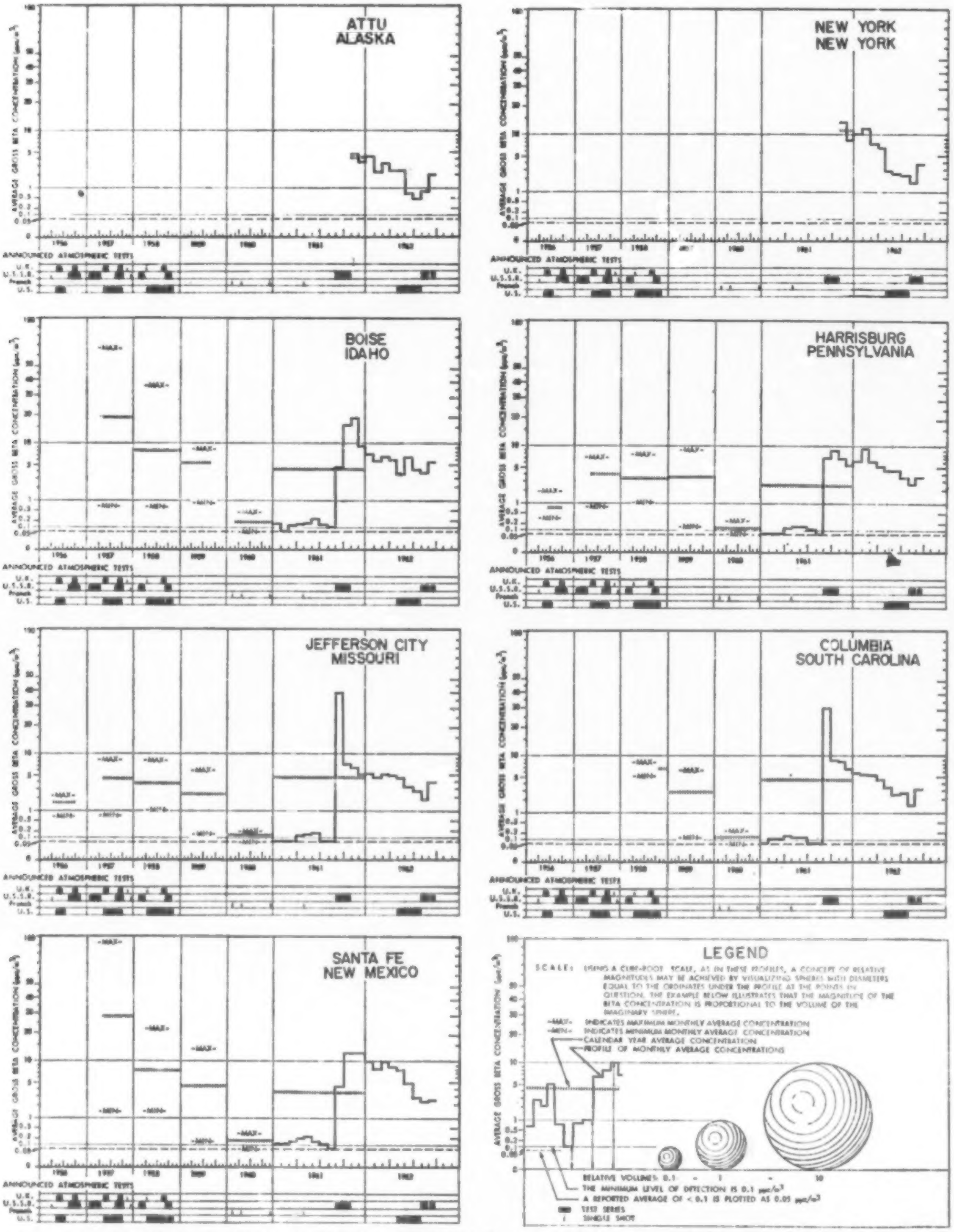

Figure 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–SEPTEMBER 1962

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THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM
August 1962

U.S. Naval Research Laboratory

Radioactivity measurements of surface air samples collected at various sites near the 80th Meridian (West) have been made since 1956. Sampling locations are shown in figure 3. This program is operated by the U.S. Naval Research Laboratory (NRL) with the cooperation of interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile, which collect the samples and forward them to NRL for analysis. Partial financial support of this program is provided by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

The sampling procedure involves drawing air continuously for a 7-day period, at a rate of approximately 1200 cubic meters per day, through an 8-inch diameter, high-efficiency filter, using a positive-displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. Data are not extrapolated to time of collection.

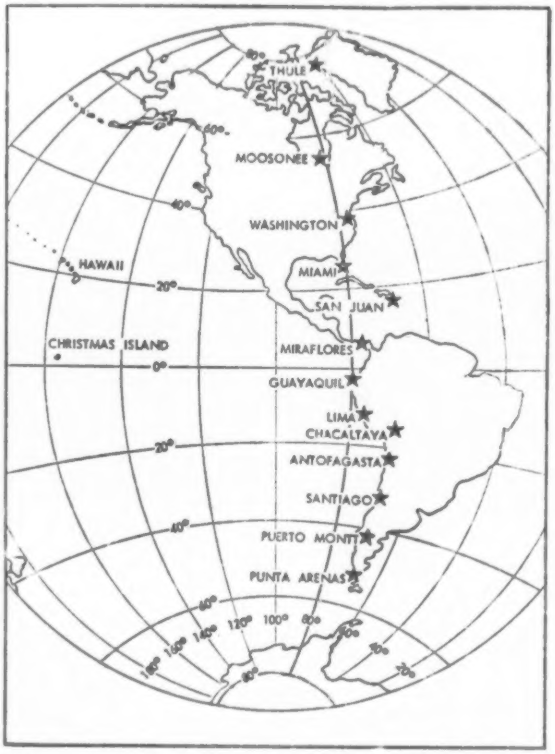
THULE
MOOSONEE
WASHINGTON
MIAMI
SAN JUAN
HAWAII
CHRISTMAS ISLAND
MIRAFLORES
GUAYAQUIL
LIMA
CHACALTAYA
ANTOFAGASTA
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
80°
60°
40°
20°
0°
20°
40°
60°
80°
180°
160°
140°
120°
100°
80°
60°
40°
20°

Figure 3.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

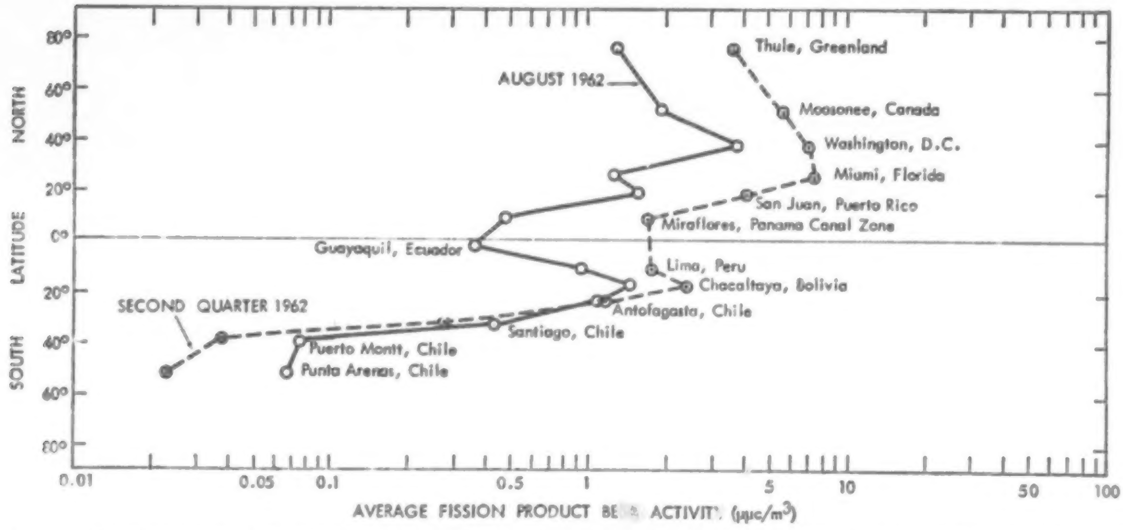

Figure 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST) AUGUST 1962

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL[a], AUGUST 1962

[Average concentrations in $\mu\mu c/m^3$]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, P. R.	Mauna Loa, Hawaii[b]	Miami, Florida	Washington, D. C.	Moosonee, Ontario Canada	Thule, Greenland
1 2 3 4 5 6	0.067	0.067	[c]—	1.49	1.64	1.42	0.495	0.756	1.62	1.81	2.28	3.96	2.21	2.24
7 8 9 10 11 12 13	0.035	0.087	—	0.994	—	0.698	0.269	0.630	1.78	1.84	1.12	—	1.69	1.28
14 15 16 17 18 19 20	0.058	0.082	— 0.603	0.869	—	0.760	0.328	0.413	1.78	1.64 —	1.32	3.28	1.41	0.327
21 22 23 24 25 26 27	0.117	0.082	0.291	1.26	1.36	0.882	0.326	0.285	1.05	—	0.832	3.44	2.28	1.27
28 29 30 31	0.030	0.080	0.430	0.90	1.26	0.954	0.404	0.167	1.41	—	0.639	5.00	2.60	1.45
Weighted average	0.064	0.080	0.432	1.11	1.44	0.927	0.357	0.468	1.53	1.78	1.26	3.78	1.98	1.27

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period or that portion of the sampling period occurring in August 1962.

[b] Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters) and about equally distant north and south of the equator.

[c] Dash indicates samples were not received.

Intercalibration of Some Air Monitoring Systems

L. B. Lockhart, Jr. and R. L. Patterson, Jr.[1]

Introduction

The various systems employed for monitoring fission products in the atmosphere, both in this country and abroad, have been developed more or less independently of each other and consequently often employ vastly different techniques for collection, evaluation, and standardization. These differences have been clearly apparent at those sites where two or more systems make concurrent collections as, for example, at Washington, D.C., and Moosonee, Canada where the NRL 80th Meridian Network coincides with the Public Health Service Radiation Surveillance Network and the Canadian Air Monitoring Network, respectively. The desirability of obtaining factors for directly comparing results obtained by any one network with those obtained by the others is obvious.

The U.S. Naval Research Laboratory, with the cooperation and active participation of the U.S. Public Health Service and the Radiation Protection Division of the Canadian Department of National Health and Welfare, undertook the collection of airborne fission products at Washington, D.C., through use of the standard equipment and procedures employed by the different systems (*1,2,3*). After preliminary evaluation for radioactivity, the exposed filters were returned to the parent organizations for evaluation by their customary procedures.

Experimental Procedures

Equipment from each of the systems was set up on the roof of a building at NRL and

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[1] Dr. Lockhart is Head of the Physical Chemistry Branch, and Mr. Patterson is Head of the Radiochemistry Section, Physical Chemistry Branch, U.S. Naval Research Laboratory, Washington, D.C.

operated side-by-side for several months using filters supplied by the parent organizations and employing the normal operating procedures of each system. The characteristics of the various systems are compared in table 1. The sampling period during this study was generally 24 hours ending at 3:00 p.m. (1500) local time. Weekend collections were made with the 80th Meridian and Canadian systems which could operate unattended for this period of time.

Each of the collecting systems was calibrated for air flow against the same flow meter (Fischer and Porter, 55 CFM capacity) and the flow rate routinely recorded at the beginning and end of each collection.

On removal of the samples from the collector, one or more of them was followed for decay during a 16–hour period so that corrections for the presence of natural activity in the samples at the time they were evaluated at NRL (16–18 hours after collection) could be made (*4*). The samples were then forwarded to the parent organizations for measurement.

Some measurements were made in March and early April 1962 in a preliminary study of NRL and PHS collectors and counting techniques. Parallel operation of the samplers from the three operating networks was carried out during the period April 20–June 18, 1962. During this period the primary source of the fission product radioactivity in the air in the Washington area was the U.S.S.R. test series of 1961.

Results

The large quantity of data accumulated in this project is presented in detail elsewhere (*5*) and only a summary of the data and results is reported here.

The preliminary studies indicated that the two sampling systems, employing similar filters but different types of blowers, were adequately calibrated at NRL as to the volume of air sampled and that a major difference did exist in the volume calibration using the orifice plate and gage supplied by PHS. Furthermore, a consistent difference existed between the disintegration rates determined at NRL and PHS, most probably as a result of the different radioactive standards employed.

The results of the measurements made at NRL on the samples collected through use of the PHS, Canadian and 80th Meridian systems are summarized in table 2. The small standard deviation of single determinations of the activity ratios (less than 10%) indicates that each collector is effectively sampling the same air mass untroubled by recycling of filtered air. As far as effectiveness of sample collection is concerned, the Canadian and 80th Meridian systems are essentially identical while the PHS system shows a definitely lower effi-

TABLE 1.—CHARACTERISTICS OF THE AIR MONITORING SYSTEMS STUDIED IN THE INTERCALIBRATION PROGRAM

System elements	Radiation Surveillance Network U.S. Public Health Service	Air Monitoring Network Radiation Protection Division Canadian Dept. of Health and Welfare		80th Meridian Network U.S. Naval Research Laboratory
Air Sampler				
Blower, type	Centrifugal	Positive–displacement		Positive–displacement
Capacity*	40–46 CFM	17–24 CFM		26–29 CFM
Motor, type	Free running	Constant speed		Constant speed
		(a)	(b)	
Filter type	Cellulose, carbon–loaded	glass fiber	Polystyrene	Cellulose/asbestos
Designation	MSA BM-2133 (CR-17651)	Hurlburt 934AH	Microsorban (Gelman Instrument Co.)	Army Chemical Corps Type 6
Size (dia.)	4 inch	4 inch	4 inch	8 inch
Effective area	9.6 sq. inches	9.3 sq. inches	9.3 sq. inches	41.3 sq. inches
Volume measurement (at field stations)	Orifice plate and gage	Prior calibration		Prior calibration
Sample processing	Counted in glassine envelope	2 inch disc removed for counting		Ashed at 640°C Compressed to 1-1/8″ dia. disc
Counting Procedure				
Counter, type—size (dia.)	Gas flow proportional—7½ inch	Gas flow Geiger—2 inch		Organic quenched Geiger—2 inch
Window thickness		0.8 mg/cm²		1.4 mg/cm²
Geometry	2π	2π		2π
Background	500 c/m	13 c/m		10 c/m
Counting time	1 min.	preset count of 900		Preset count of 10,000
Standard	Sr^{90} (Y^{90})	Sr^{90} (Y^{90})		Ra (D, E, and F)
Activity Recorded	Extrapolated to end of collection	Extrapolated to end of collection		At time of measurement (2 weeks after collection)

* As measured at NRL with clean filters in holder.

TABLE 2.—AIR MONITORING SYSTEMS ACTIVITY RATIOS EVALUATED AT NRL

Systems Compared	Number of Measurements	Mean of Measured Ratios	Standard Deviation of Mean	Standard Deviation of Single Measurement
PHS Sampler / 80th Meridian Sampler	31	0.77	±0.013	±0.073 (9.5%)
PHS Sampler / Canadian Sampler	31	0.77	±0.013	±0.072 (9.4%)
Canadian Sampler / 80th Meridian Sampler	39	0.98	±0.010	±0.060 (6.1%)

ciency. This lower counting rate is entirely a function of the filter employed. The filter used by PHS has a lower measured retentivity for fission products and higher self-absorption due to deeper penetration of radioactive particles into the filter mat.

The activity concentrations reported by the parent organizations for the series of samples described above are listed in table 3. The uncorrected results presented are those that normally would have been reported by the network and are based either on an orifice plate and flow gage measurement (PHS) or on initial calibrations of the blower and filter systems (Canadian and 80th Meridian); the corrected results are based on the NRL air flow measurements. The calculated ratios listed are based on the corrected activity concentrations.

Though there is quite a spread in the activity concentrations obtained with the various systems, there appears to be a high degree of precision in the intercalibration ratios obtained. The relative activity concentrations determined by the three techniques are as follows: PHS, 0.65; Canada, 1.00; 80th Meridian, 1.12. The factors compared in this study do not indicate which system gives results that are nearest to the correct value. It is clear that the major source of disagreement between the various systems lies in the technique employed to standardize the counting equipment.

It is also recognized that the various systems will not have the same relative counting efficiency toward fission product mixtures of different beta energy distribution due either to self-absorption within the sample or to absorption by the counter window, and that some revision of the above intercalibration factors will be required when fresh fission debris is present. The usage of such varying factors would require a determination of the age of the debris in each individual collection; a more practical solution might be the experimental determination of the range of errors introduced in the above factors with nuclear debris of different ages.

The decreased precision in the measurements of the 80th Meridian samples, which require more processing and the counting of thick samples, is evident since the standard deviation of single measurements of activity ratios relative to 80th Meridian samples is higher than that of the other pairs of measurements. It appears that it would be reasonable to employ these activity concentration ratios to interconvert reported activities obtained from any one of these systems with a high degree of reliability, subject only to uncertainties in the volume of air sampled. This latter variable could easily be kept below 5 percent with a few precautions or simple measurements.

Conclusions and Recommendations

Realistic interconversion ratios for comparing radioactivity concentration data reported by several air monitoring networks have been derived which are subject to uncertainty only

TABLE 3.—AIR CONCENTRATIONS OF FISSION PRODUCT RADIOACTIVITY BASED ON ANALYSIS BY THE PARENT ORGANIZATION OF AIR FILTERS EXPOSED IN PARALLEL AT WASHINGTON, D. C.

Collection ending	Activity concentration ($\mu\mu c/m^3$) reported by[a]						Ratios of corrected activity concentration		
	USPHS		Canada		80th Meridian		PHS / Canada	PHS / 80th Meridian	Canada / 80th Meridian
	corr.	uncorr.	corr.	uncorr.	corr.	uncorr.			
April 20	2.9	3.6	4.1	[b]4.1	4.97	4.35	0.71	0.58	0.82
21	[e]—	—	—	—	—	—	—	—	—
22	—	—	—	—	—	—	—	—	—
23	—	—	—	—	—	—	—	—	—
24	4.7	5.9	7.0	[b]7.0	8.84	7.73	0.67	0.53	0.79
25	—	—	6.3	[b]6.1	9.36	8.10	—	—	0.67
26	5.5	6.9	8.1	[b]7.9	9.00	8.55	0.68	0.61	0.90
27	6.8	8.5	10.1	7.3	12.69	11.77	0.67	0.54	0.80
28	—	—	[d]7.7	[d]6.6	[d]12.68	[d]10.83	—	—	—
29	—	—	"	"	"	"	—	—	—
30	—	—	"	"	"	"	—	—	0.61
May 1	3.4	4.3	5.1	5.1	8.66	7.49	0.67	0.39	0.59
2	0.96	1.2	1.4	1.2	1.59	1.38	0.69	0.60	0.88
3	0.96	1.2	1.6	1.4	2.08	1.80	0.60	0.46	0.77
4	4.7	5.9	8.1	6.5	9.87	8.60	0.58	0.48	0.82
5	—	—	[d]8.1	[d]6.5	[d]9.82	[d]9.13	—	—	—
6	—	—	"	"	"	"	—	—	—
7	—	—	"	"	"	"	—	—	0.82
8	6.0	7.5	8.3	6.9	8.68	8.05	0.72	0.69	0.96
9	4.3	5.4	6.8	5.3	7.80	6.75	0.63	0.55	0.87
10	4.8	6.0	7.8	6.0	8.76	7.63	0.62	0.55	0.89
11	4.0	5.0	6.3	5.2	8.06	7.05	0.63	0.50	0.78
12	—	—	[d]7.2	[d]6.1	[d]8.53	[d]7.39	—	—	—
13	—	—	"	"	"	"	—	—	—
14	—	—	"	"	"	"	—	—	0.84
15	5.2	6.5	7.9	6.2	8.62	7.45	0.66	0.60	0.92
16	4.5	5.7	7.6	6.1	8.31	7.21	0.59	0.54	0.91
17	2.6	3.3	4.7	4.0	3.75	3.58	0.55	0.69	1.25
18	3.0	3.8	4.5	3.7	3.79	3.60	0.67	0.79	1.19
19	—	—	—	—	[d]7.24	[d]6.78	—	—	—
20	—	—	—	—	"	"	—	—	—
21	—	—	—	—	"	"	—	—	—
22	4.4	5.5	7.3	5.5	7.05	6.34	0.60	0.62	1.04
23	3.2	4.0	5.4	4.5	4.82	4.60	0.59	0.66	1.12
24	4.4	5.5	6.8	[b]8.0	7.05	6.87	0.65	0.62	0.96
25	4.7	5.9	6.8	[b]7.7	7.43	6.76	0.69	0.63	0.92
26	—	—	[d]5.9	[d]5.1	[d]8.35	[d]7.49	—	—	—
27	—	—	"	"	"	"	—	—	—
28	—	—	"	"	"	"	—	—	0.71
29	3.1	3.9	5.0	6.3	6.37	5.55	0.62	0.49	0.78
30	[d]2.7	[d]3.4	[d]3.9	[d]3.8	[d]3.83	[d]3.61	—	—	—
31	"	"	"	"	"	"	0.69	0.70	1.02
June 1	—	—	4.5	5.2	4.03	3.50	—	—	1.12
2	—	—	[d]4.1	[d]4.1	[d]5.73	[d]4.97	—	—	—
3	—	—	"	"	"	"	—	—	—
4	—	—	"	"	"	"	—	—	0.72
5	2.0	2.5	2.9	3.5	3.60	3.31	0.69	0.56	0.81
6	1.1	1.4	1.8	2.1	2.33	2.04	0.61	0.47	0.77
7	—	—	8.1	9.2	10.68	9.31	—	—	0.76
8	4.5	5.6	6.5	7.5	7.78	6.90	0.69	0.58	0.84
9	[d]6.1	[d]7.7	[d]8.3	[d]8.7	[d]7.79	[d]7.30	—	—	—
10	"	"	"	"	"	"	—	—	—
11	"	"	"	"	"	"	0.73	0.78	1.07
12	3.3	4.1	5.0	[b]5.7	5.69	5.13	0.66	0.58	0.88
13	0.74	0.93	1.3	[b]1.5	1.45	1.25	0.57	0.51	0.90
14	0.37	0.46	0.55	[b]0.65	0.68	0.60	0.67	0.54	0.81
15	2.6	3.2	4.5	[b]5.6	11.21	9.80	0.58	—	—
16	[d]6.2	[d]7.8	[d]9.1	[d]8.7	[d]11.03	[d]10.31	—	—	—
17	"	"	"	"	"	"	—	—	—
18	"	"	"	"	"	"	0.68	0.56	0.83
Average							0.65	0.58	0.87
Standard deviation of the mean							±0.009	±0.017	±0.024
Number of measurements							31	30	38
Standard deviation of a single measurement							±0.048 (7.4%)	±0.091 (15.7%)	±0.147 (16.9%)

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[a] Uncorrected results that would have been reported following the normal procedure in use in the network. The corrected results include a volume correction based on the measured air flow through the filter.

[b] Indicates glass fiber filter used rather than Microsorban filter.

[c] Dash indicates no sample taken.

[d] Value shown represents continuous sample taken during the period including this date and one or two succeeding days shown by ditto marks.

[e] Sample contaminated; count disagrees markedly with preliminary evaluation.

in the quantity of air sampled at the various sites. The relative activity values obtained by the three networks are as follows: U.S. Public Health Service Radiation Surveillance Network, 0.65; Canadian Air Monitoring Network, 1.00; NRL 80th Meridian Network, 1.12.

The above interconversion factors have been determined for fission product mixtures whose major component was 6–8 months old. Some minor differences are to be expected when there is present in the air a fission product conglomerate consisting of younger debris due to the varying counter response to the different beta spectra of old and young debris; of more importance is the fact that no correction for radioactive decay is applied to the 80th Meridian collections.

In order to better measure the volume of air sampled it would be highly desirable for all networks to employ positive displacement blowers driven by constant speed motors and for each unit to be equipped with a calibrated pressure gage which is read at the beginning and end of each collection. The use of one of a number of available filter media having essentially 100% retention for fission products at the face velocity employed in the sampling device is highly recommended.

Acknowledgement

The U.S. Naval Research Laboratory and the authors wish to express their appreciation for the encouragement and cooperation given this project by Messrs. Arve H. Dahl, John Villforth, Frank Conlon, and Donald L. Snow of the U.S. Public Health Service, U.S. Department of Health, Education and Welfare and by Drs. A. H. Booth and Peter Bird of the Radiation Protection Division, Department of National Health and Welfare, Canada. Partial financial support was supplied by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

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SECTION II.—FOOD

Radionuclides in Institutional Diet Samples

March 1962–June 1962

Division of Radiological Health, Public Health Service

The determination of radionuclide concentration in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is being administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a controlled population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from exclusive, well-funded boarding schools to orphanages with severe economic limitations. Each institution (sampling point) is located in a community monitored by both the Pasteurized Milk Network and the Drinking Water Analysis Program. The analytical data from these two sampling activities are used to supplement the findings from the Institutional Diet Sampling Program.

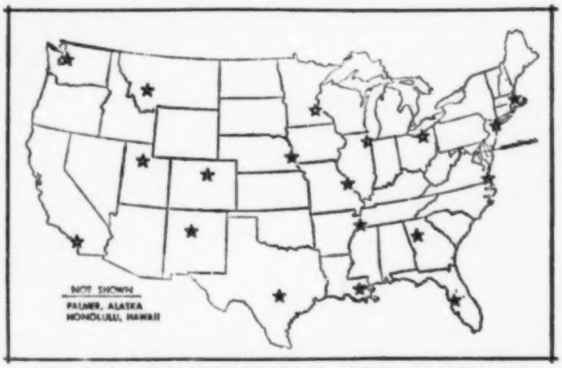

Figure 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, JUNE 1962

Sampling Procedure

In general, the sampling procedure is the same in each case. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Meals are frozen following collection. On completion

99<

of the total sample, it is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three containers: one containing solid food less seed pits, rinds, shells, bones, etc. that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, ice cream, etc.; and one containing soft drinks, coffee, tea, etc. A record of the contents of each meal and the approximate weight of each item is recorded by the institution's dietician and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Program

Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by colorimetric technique. Because calcium and phosphorus compounds may have an effect on the uptake of important boneseeking radionuclides such as strontium-89 and strontium-90, they are included in the analytical program.

The radioanalysis program is designed around three basic procedures: (*1*) gamma spectroscopy, (*2*) chemical separation of strontium-89 and strontium-90 with subsequent counting, and (*3*) total radium analysis. In the absence of interference, other than naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per kilogram basis are: I^{131}, 10 μμc/kg; Cs^{137}, 5 μμc/kg; and Ba^{140}, 10 μμc/kg. Approximate minimum detectable concentrations for Sr^{89}, Sr^{90}, and total radium are: 5, 1, and 1 μμc/kg, respectively.

TABLE 1.—INSTITUTIONAL DIETARY INTAKE

Determination	Month (1962)	Alaska Palmer	California Los Angeles	Colorado Denver	Florida Tampa	Georgia Atlanta	Hawaii Honolulu	Illinois Chicago	Louisiana New Orleans	Massachusetts Boston
Total weight (kg/day)	Mar	1.67	1.41	2.24	1.69	1.70	2.00		2.04	2.41
	Apr	1.69	1.59	2.30	1.59	1.80	2.09	1.50	2.10	2.33
	May	1.36	1.79	2.02	1.65	1.48	2.24	1.68	2.03	1.93
	Jun	1.22		0.88	1.62	1.45	2.43	1.72	2.41	1.51
Calcium (g/day)	Mar	1.1	1.1	1.7	0.9	0.8	0.8		1.2	1.7
	Apr	1.5	0.7	2.3	1.1	1.1	0.8	0.8	1.3	1.7
	May	1.2	0.9	2.1	0.8	0.7	1.3	1.0	1.3	1.3
	Jun	0.6		1.8	0.9	0.7	0.7	0.6	1.4	0.4
Phosphorus (g/day)	Mar	4.6	3.9	6.3	3.9	3.4	3.2		4.1	5.4
	Apr	3.7	3.5	5.3	4.1	3.7	3.8	4.4	7.0	6.4
	May	3.8	3.8	5.6	4.1	3.4	5.3	4.5	4.1	3.7
	Jun	2.8		8.0	3.3	2.7	4.1	2.0	3.9	1.9
Potassium (g/day)	Mar	4.1	2.0	5.5	2.1	2.4	3.6		2.4	3.8
	Apr	3.0	3.0	4.5	2.4	2.3	2.3	2.3	2.7	3.7
	May	2.2	2.7	3.0	1.9	2.1	2.7	2.8	3.1	4.1
	Jun	1.6		2.9	1.9	1.5	3.2	3.9	3.3	3.1
Total Radium (μμc/day)	Mar	3.5	2.0	4.0	2.0	3.0	2.0		2.0	<3.0
	Apr	1.0	1.0	10.0	7.5	4.0	4.0	<2.0	4.0	<3.0
	May	1.0	2.0	14.0	<1.0	4.0	9.0	<2.0	<2.0	<2.0
	Jun	1.0		11.0	2.5	2.0	7.0	<1.0	<3.0	1.0
Strontium-89 (μμc/day)	Mar				<10	41			186	<15
	Apr				<10	126		<10	195	<15
	May			110	5	40	<5	35	145	<15
	Jun	35		55	<10	35	25	<5	160	5
Strontium-90 (μμc/day)	Mar	4	5	6	7	8	5		24	16
	Apr	16	3	8	9	16	9	4	25	11
	May	4	2	<1	4	12	<1	13	32	3
	Jun	5		20	8	10	17	3	36	2
Iodine-131 (μμc/day)	Mar	<10	<10	<10	<20	<20	<10		<20	<25
	Apr	<10	<10	<10	<20	<20	<10	<15	<25	<25
	May	<10	<10	30	<20	<20	90	30	<20	<15
	Jun	<10		<10	<20	<20	50	<10	<30	<10
Cesium-137 (μμc/day)	Mar	17	<5	22	20	41	40		49	21
	Apr	25	<5	<5	43	63	30	8	84	58
	May	5	<5	20	40	<10	55	20	130	68
	Jun	20		<5	<10	40	75	170	105	115
Barium-140 (μμc/day)	Mar	<10	<10	<10	<20	<20	<10		<25	<10
	Apr	80	<10	<10	<20	<20	<10	<15	<25	<25
	May	<10	<10	<10	<20	<20	110	<20	<20	<15
	Jun	<10		20	<20	<20	120	<10	<30	<10

Total radium is determined by ashing, separation, and coprecipitation of radium and barium as sulfate or chromate. After transfer to planchets, alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226 would therefore be moderately high. The acquisition of special equipment is projected to perform specific determinations of radium-226.

Data Treatment

Table 1 presents the dietary intake data expressed on a per-day basis from March 1962 through June 1962. Values previously published in *RHD* show the daily total ash and total water content of the samples.[1] As these items are not directly related to radionuclide intake, they are not reported. The reported iodine-131 values are the daily intake based on the iodine-131 content of the sample at the end of the sample collection period. The true iodine-131 intake may therefore be somewhat greater than the reported values.

Monthly network averages for strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 are shown in figure 2. Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the convention employed is that all "less than" data are assumed to be equal to the full "less than" value. A

(BASED ON A 7 DAY COMPOSITE SAMPLE)

Minnesota Minneapolis	Missouri St. Louis	Montana Helena	Nebraska Omaha	New Mexico Albuquerque	New York New York	Ohio Cleveland	Tennessee Memphis	Texas Austin	Utah Salt Lake City	Virginia Norfolk	Washington Seattle	Network average
	3.01	2.34	2.03	1.37	1.60	1.47	1.74	2.69	1.07	1.47	2.76	1.93
1.70	3.20	2.44	1.74	1.70	1.53	1.73	2.39	2.99	1.26	1.90	2.83	2.04
1.60	2.93	2.71	1.57	1.70	1.74	1.60	1.94	3.08	1.57	1.23	2.73	1.93
1.53	3.24	2.55	1.76	1.50	1.40	1.94	1.65	2.95		1.83	2.79	1.91
	1.8	1.6	1.3	0.8	0.7	1.1	1.2	1.3	0.5	0.7	1.9	1.2
1.0	2.0	1.4	1.0	1.2	0.8	1.2	1.2	1.7	1.3	0.9	2.1	1.2
0.5	2.0	1.4	1.4	1.2	0.9	1.1	1.3	1.7	0.8	0.5	1.9	1.2
0.8	2.1	1.4	1.2	1.2	0.9	0.5	0.6	1.7		0.8	1.9	1.1
	8.2	6.4	5.3	3.1	3.0	3.6	4.1	5.6	2.3	3.0	7.9	4.6
3.9	7.3	5.1	3.6	3.8	3.3	3.7	3.9	7.8	3.4	4.0	6.7	4.7
2.9	7.3	5.4	4.1	3.6	2.1	4.5	5.2	6.9	3.1	2.4	5.7	4.4
3.4	8.1	5.7	4.4	4.9	1.5	1.5	2.9	6.3		4.9	8.6	4.3
	7.5	5.3	4.4	2.8	2.3	2.6	2.3	3.6	2.2	1.6	5.2	3.5
2.0	6.0	4.5	2.5	3.3	2.1	2.4	7.1	7.1	2.5	2.7	4.6	3.5
2.2	5.3	3.5	2.9	1.7	3.2	2.3	2.9	3.5	2.2	1.9	3.8	2.9
1.8	4.9	3.3	2.3	2.3	2.7	4.7	1.7	3.1		2.1	3.4	2.8
	9.5	7.5	6.0	1.5	2.0	2.0	2.5	4.0	2.0	3.5	6.0	3.6
<1.0	7.0	4.0	2.0	2.0	<2.0	<2.0	4.5	<3.0	3.0	4.0	5.0	3.6
<2.0	6.0	8.0	<1.0	3.0	6.0	<2.0	<2.0	<3.0	2.0	1.5	5.0	<3.7
6.0	8.0	5.0	<1.0	<1.0	<1.0	1.0	<2.0	<2.0		2.0	15.0	3.8
					<10	<10	129	47		42		54
					<10	<10	135	249		66		83
					<15	10	110	80		40		51
80	160	<5	15	<5	5	5	50	85		235		54
	17	6	3	4	7	6	15	13	3	9	19	9.3
6	15	5	2	4	3	7	22	12	4	18	11	10.1
<1	9	8	8	<1	5	10	23	20	3	10	25	9.3
15	32	<1	4	<1	2	2	11	21		20	33	12.8
	<10	<10	<10	<10	<20	<15	<20	<30	10	<15	<10	<15
<10	<10	<10	<10	<10	<20	<20	<25	<30	<10	<20	<10	<16
<10	<10	<10	<10	<10	<15	<20	<20	<30	<10	<10	<10	<20
50	<10	50	<10	<10	<10	<10	<20	<30		<20	200	<31
	<5	35	10	<5	<10	15	<10	38	16	<10	28	21
<5	<5	25	<5	<5	15	25	36	82	<5	29	35	28
<5	15	15	10	<5	7	25	<10	170	<5	55	110	37
55	80	65	<5	25	70	110	15	65		25	125	62
	<10	<10	<10	<10	<20	<15	<20	<30	27	<15	<10	<16
20	80	160	<10	<10	<20	<20	<25	<30	<10	<20	60	<33
<10	<10	<10	<10	<10	<15	<20	<20	<30	<10	<10	<10	<19
90	<10	150	<10	50	<10	<10	<20	<30		<20	110	<40

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[1] Previous coverage in *Radiological Health Data*:

Period	Issue
January 1961-February 1962	*July 1962*

"less than" sign (<) precedes an average in table 1 if the uncertainty due to individual sample "less than" values in the average exceeds 20 percent.

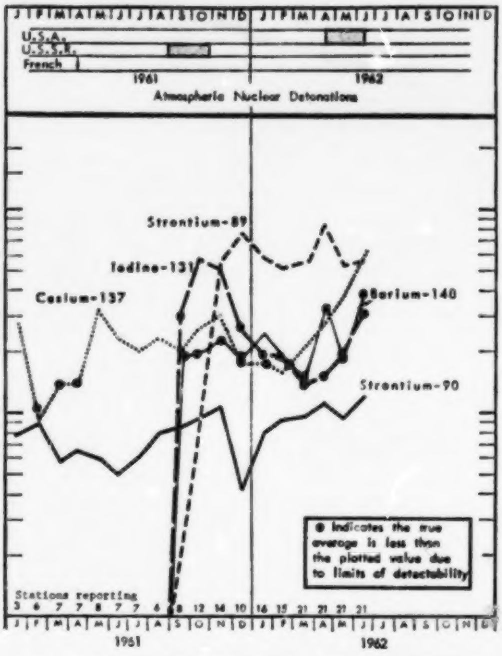

Figure 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—NETWORK AVERAGES

For rapid comprehension, the data are presented graphically in figures 4–10 as station distributions versus daily intake. These are not graphs of continuous functions as might be implied by their appearance. The construction of these graphs is shown in figure 3. In this graph the "total intake" of food is divided into six ranges (< 1.00, 1.00–1.49, 1.50–1.99, 2.00–2.49, 2.50–2.99, and 3.00–3.50 kg/day) and the number of stations in each range is noted and plotted as a bar graph. The maximum of each bar is connected by a smooth curve. This type of construction is used for each month for each item represented in figures 4–10. It should be recognized that there are only 21 stations and that a variation of three stations or 14 percent of the total may not be significant in considering trends in the data.

Discussion of the Data

During the 4-month period reported, the dietary intake of strontium-90 ranged between < 1 and 36 μμc/day with arithmetic average values of 9.3, 10.1, 9.3, and 12.8 μμc/day for the months of March, April, May and June 1962 respectively. These averages lie within the lowest Radiation Protection Guide (RPG) limit of the Federal Radiation Council of 0 to 20 μμc/day for strontium-90 (2, 3). The May 1962 *Radiological Health Data* contains a discussion of environmental radiation protection standards which should be referred to for an understanding of the RPG (3).

The dietary intake of total radium ranged between < 1.0 and 15.0 μμc/day with 80 percent of the stations reporting less than 6 μμc/day during the entire period. Assuming the radium-226 component of the total radium activity is 30 percent, the intake of radium-226 via the diet probably approaches the Range I level of the RPG (0 to 2 μμc/day for radium-226).

Following the resumption of nuclear weapons testing in the atmosphere in 1961, iodine-131 dietary intake increased from non-detectable to a station high of 228.5 μμc/day (*4*). A peak network average of 56.6 μμc/day occurred in October 1961. During the period of March 1962–June 1962 the station high was 200 μμc/day and the peak network average of < 30.5 μμc/day occurred in June 1962. These averages are in Range II of the iodine-131 RPG (10–100 μμc/day).

The cesium-137 dietary intake network averages have increased from 21.3 μμc/day in March 1962 to 62.1 μμc/day in June 1962. The 1961 network high of 32.6 μμc/day occurred in May. During March, April, and May 1962 most of the stations reported values less than 40 μμc/day. During June 1962, however, the values reported are distributed approximately evenly between 0 and 120 μμc/day (see figure 10).

Comparison of the total dietary intake levels of strontium-90 with those previously reported for milk confirms previous estimates that the milk may account for approximately one-half of the dietary intake of this radionuclide.

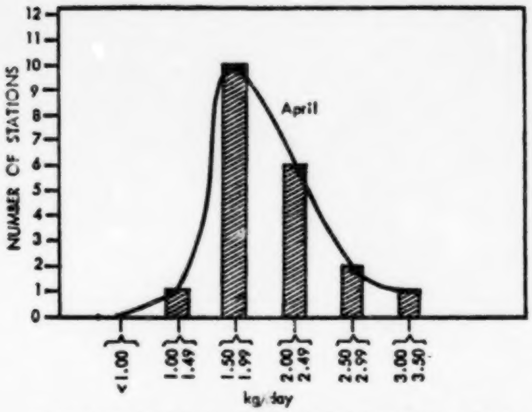

FIGURE 3 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

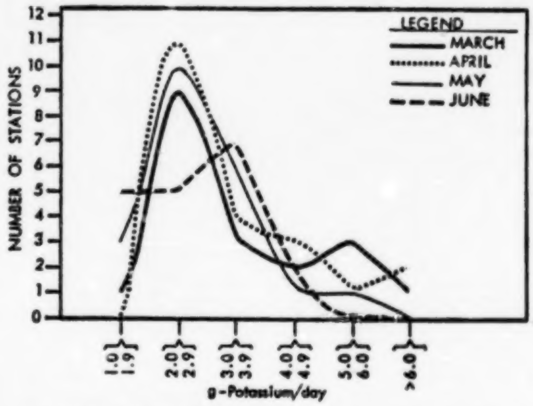

FIGURE 6 — DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY POTASSIUM INTAKE

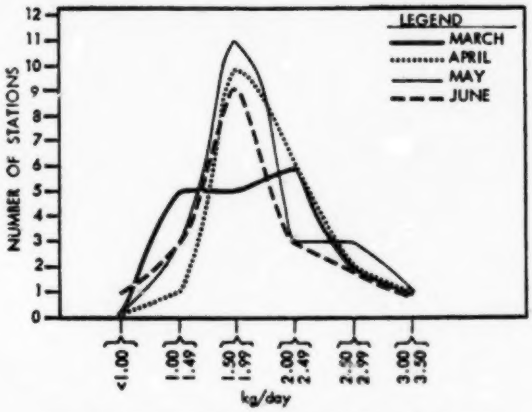

FIGURE 4 — DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

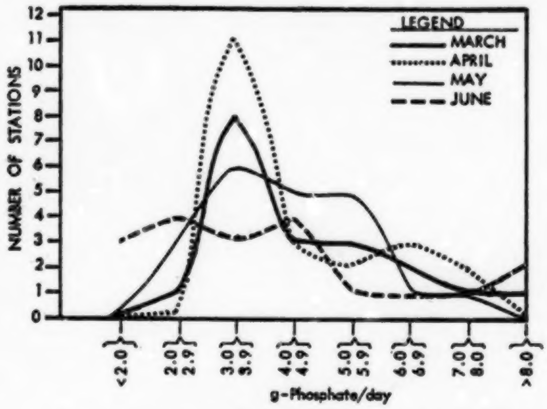

FIGURE 7 — DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY PHOSPHATE INTAKE

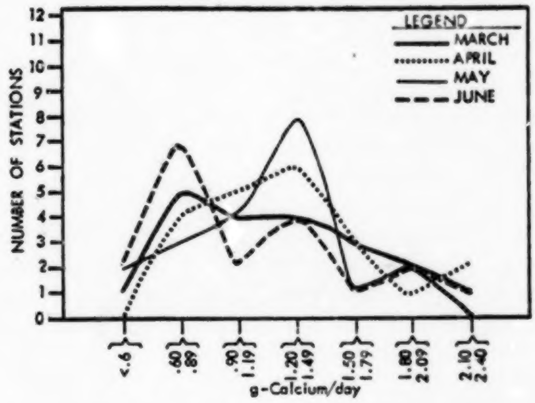

FIGURE 5 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CALCIUM INTAKE

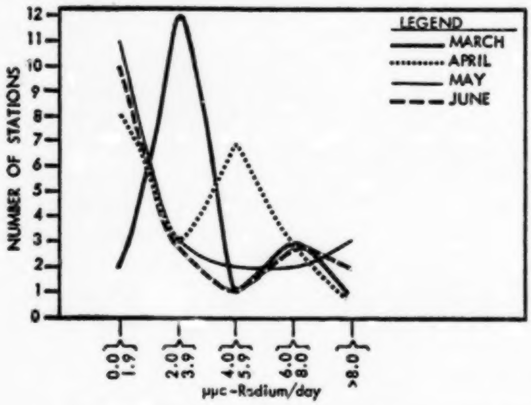

FIGURE 8 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY TOTAL RADIUM INTAKE

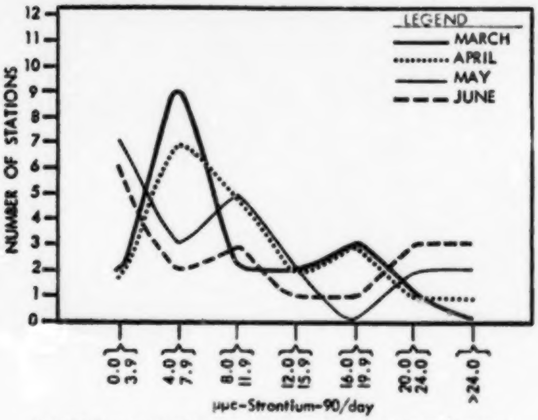

FIGURE 9 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-90 INTAKE

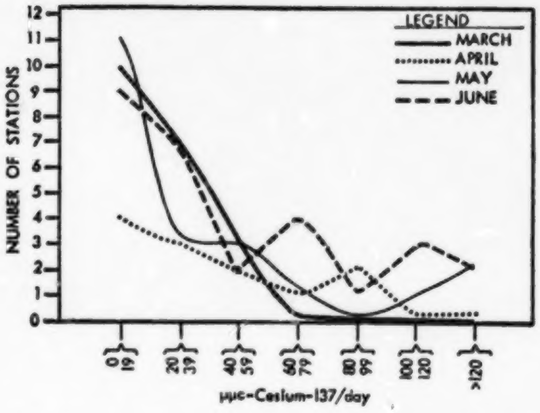

FIGURE 10 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CESIUM-137 INTAKE

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52*:1391–400 (September 1962).

(*2*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.

(*3*) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, III*:159–65 (May 1962).

(*4*) Federal Radiation Council: *Health Implications of Fallout from Nuclear Weapons Testing Through 1961*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 1962), price 15 cents.

Survey of Radioactivity in Food[1]

1960, 1961, and 1962

Division of Pharmacology
Food and Drug Administration

Over the past five years, the Food and Drug Administration (FDA) has conducted an extensive surveillance program on radioactivity in human and animal food, both domestic and imported. This program has been largely directed at assessing the degree of contamination by strontium–90 and cesium–137 in individual foods, and more recently in the total diet. In addition, considerable attention has also been focused on commercial processing of foods in an attempt to learn what effects such operations have on removing radioactive contamination. Finally, since resumption of atmospheric testing, there have been several local fallout situations signalled by the findings of the Radiation Surveillance Network of the Public Health Service. When these have occurred, the Food and Drug Administration, through its field Districts, has sampled vegetation and made analyses for iodine–131.

All the 18 FDA Field Districts are involved in the collection of samples for analysis. There are now 10 Districts (Seattle, San Francisco, Dallas, Denver, Kansas City, Detroit, Atlanta, Minneapolis, Baltimore and Philadelphia) which have the capabilities for making strontium–90 determinations. All Districts are also supplied with portable monitoring equipment sufficiently sensitive to be useful for screening purposes. Ten of the Districts are about to acquire semi-portable scintillometers which will be useful in measuring total gamma activity and also in giving a rough quantitation of iodine–131.

In Washington, the Division of Pharmacology has complete laboratory facilities for

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[1] Based on data presented by Dr. Edwin P. Laug, Chief, Radioactivity Branch, FDA, at the International Training Course on Surveys For Radionuclides in Foods, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, October 8, 1962.

measuring strontium–90 and total beta activity. This laboratory also makes cesium–137 and iodine–131 determinations by gamma spectrometry. A system of interlaboratory checks on methodology is also maintained. All analyses for strontium–90 made by the District laboratories are checked, collated, and interpreted at the central laboratory and the results published at frequent intervals. Present capability of the Food and Drug Surveillance system for assaying strontium–90 in foods is about 300 samples per month.

Surveillance for Strontium–90 in Individual Foods

Program: Samples are not collected according to a regular schedule or fixed geographical grid. The major growing areas for all products are covered at intervals, usually coinciding with harvest dates for the specific crop. Decisions as to what products to sample, how often, and under what priority are reviewed at intervals and incorporated into the surveillance program. A revised program is issued about once a year. In 1960, 1500 individual food samples were collected and analyzed; last year and again this year, the number was increased to 3500 per year.

Kinds of Products: A preponderance of foods collected are raw agricultural products, but animal fodders and forage are also included. There are roughly 50 different categories. The raw food samples are usually unwashed, unpeeled, and in the condition in which they would be found in a warehouse or store. Most imports are raw and unprocessed also (tea bales, coffee beans, and cocoa beans). As processed samples are collected, an attempt is made to identify the raw lot from which the finished product is manufactured.

Collection Methods: All samples are collected by FDA inspectors, either directly from the individual grower or from the storage sheds where crops are assembled before shipment. Import samples are usually collected at dockside. Collection records kept by the inspector include date of collection, date of harvest, date of planting, name of grower or growers, location of farm by county and State (or foreign country), and name and location of marketing cooperative or dealer. As manufactured items are collected, information on the source of the raw materials is also included.

Surveillance for Cesium–137 in Individual Foods and Total Diet

About 10 percent of all samples collected for strontium–90 analyses are also examined for cesium–137. The latter analyses are made at the Washington laboratory on a 400–channel gamma spectrometer.

Surveillance for Iodine–131

As in the case of strontium–90, samples are not collected according to a fixed schedule. A formal sampling program has not been developed. Iodine–131 surveillance activities are geared to local fallout occurrences for which the alert usually comes from the Public Health Service Radiation Surveillance Network. So far, FDA has participated on two occasions, Fall 1961 and July 1962. At both times there were elevated iodine–131 values in milk, and interest focused on measurements of iodine–131 in grasses and leafy vegetables. Because of the short half–life of iodine–131, it is necessary to have facilities for measurement systematically dispersed throughout the country. At present only the Washington laboratory of FDA can make iodine–131 analyses. When facilities become available at the districts, FDA may be able to develop a formal program.

METHODOLOGY

Strontium–90: The method currently used in the FDA laboratories for the analysis of strontium–90 is essentially that outlined in the HASL Manual of Standard Procedures NYO–4700 (*1*). The method involves reduction of the unwashed and unpeeled food to an ash at 550 to 600° C, solution of the ash in hydrochloric acid, isolation of strontium and calcium as oxalates, and separation of strontium from calcium in concentrated nitric acid. After scavenging operations with barium chromate and yttrium hydroxides to remove radium and lanthanides, respectively, strontium–90 is determined either by isolation and measurement of the daughter product yttrium–90 at secular equilibrium, or by direct measurement of strontium–90 with correction for ingrowth of daughter product yttrium–90. The second procedure has an advantage in that it obviates the three–week delay period necessary for ingrowth of yttrium–90. Since this method does not differentiate between the different isotopes of strontium present during and after atmospheric tests of nuclear weapons (about 5 percent strontium–89 remains after 8 months), this method is not currently applicable. At present, the first method is being used.

Cesium–137 and Iodine–131: All analyses for these nuclides are made on a 400–channel gamma spectrometer. No chemical processing is required, as the samples are finely chopped or comminuted raw and placed in a plastic 3.7–liter Marinelli beaker that fits over a 3 x 3–inch cylindrical sodium iodide crystal. Determinations are made by integrating the counts under the characteristic peak of each nuclide (I^{131}–0.36 Mev; Cs^{137}–0.66 Mev) with allowances for background and the influence of adjacent peaks.

RESULTS

Strontium–90 in Individual Foods: The results presented are for foods harvested and collected in 1960, 1961, and 1962. They have been arranged without identifying time or source of harvest in order to demonstrate differences between varieties and categories only. Time and location parameters will be discussed later.

Table 1 lists the categories of food in descending order of strontium–90 content, and table 2 lists the strontium–90 content of foods by categories and varieties. The following categories were selected: vegetables, root vegetables, fruits, grains, dairy products, sea foods, nuts, beverage products, and spices. A total of 97 varieties are represented by 2,450 individual samples.

Statistical evaluations of these data have not been attempted. However, inspection shows that some of the differences in strontium–90 between products must be highly significant. In other cases it is sufficient merely to call attention to trends, which may later be more precisely defined with a larger sampling.

Vegetables: Generally, the leafy type carry the largest burden of strontium–90; most notable are parsley, collards, and kale. Of the legumes, soybeans and snap beans contain more strontium–90 than lima beans and peas. The difference in strontium–90 content between cauliflower and broccoli among the brassicae is difficult to explain considering the similarity of growth habit.

Root vegetables: Most striking is the difference in strontium–90 content between white potatoes and sweet potatoes. The former have the lowest concentration of strontium–90 in this category.

Fruits: With the exception of the berries, fruits carry, on the average, one–tenth as much strontium–90 as the vegetables. Notably low are tomatoes, apples, pears,

TABLE 1.—STRONTIUM–90 CONTENT OF FOODS 1960, 1961, 1962

Category	Number varieties	Number samples	Average (pc/kg)	Range (pc/kg)
Tea leaves	1	137	387	19 –1630
Spices	10	51	196	1.9–2590
Dairy products	2	81	41	2.1– 416
Vegetables	22	628	22	0.0– 299
Nuts, shelled	6	82	22	0.0– 119
Grains	6	294	17	0.0– 166
Coffee beans	1	94	17	1.8– 48
Cocoa beans	1	31	14	7.3– 25
Root vegetables	7	352	6.6	0.0– 104
Fruits	24	412	5.0	0.0– 110
Eggs	1	19	1.9	0.4– 35
Sea foods	9	161	1.0	0.0– 9.8

and peaches, and notably high are blueberries, cranberries, and strawberries.

Grains: Outstandingly low levels of strontium–90 in corn and rice were observed.

Dairy products: The findings on cheese and processed milk continue to confirm what has been demonstrated in fresh milk. High levels of strontium–90 in cheese would be expected since this is a "concentrated" product from milk. Egg substance contains very little strontium–90 but egg shell contains over 100 times as much. This has been tabulated earlier (*2*). Egg shells are of interest, since they are occasionally processed as a source of calcium.

Sea Foods: Sea foods are generally the lowest source of strontium–90 of all products examined.

Nuts: Outstandingly high in strontium–90 content are brazil nuts and peanuts. Other evidence has shown that brazil nuts concentrate radium from the soil. They appear to take up strontium–90 from the soil in a similar manner, although translocation from leaves cannot be ruled out.

Beverage products: The comparatively high value for tea has been confirmed many times. It may be assumed that a large proportion of the strontium–90 comes from surface contamination. On the other hand, coffee, cocoa beans and nuts, all being protected from surface contamination, must receive the strontium–90 by translocation.

Spices: The extremely high values shown for some of the spices are striking. However, because of the very small contribution of such products to the total diet, the results are merely academic.

TABLE 2.—STRONTIUM–90 CONTENT OF FOODS, 1960–1962

Variety	Number samples	Average (pc/kg)	Range (pc/kg)
Vegetables			
Artichokes	3	6.5	4.0– 8.1
Asparagus	16	3.3	0.3– 12
Beans, lima	25	6.0	0.4– 27
Beans, snap	80	16	1.0– 98
Broccoli	13	20	0.2– 64
Brussel sprouts	5	5.8	0.2– 8.1
Cabbage	101	12	0.7– 51
Cauliflower	15	4.6	0.6– 10
Celery	78	10	0.8– 60
Collards	13	117	29 – 299
Eggplant	2	5.4	4.3– 6.5
Kale	3	132	22 – 237
Lettuce	114	17	0.3– 214
Parsley	25	87	21 – 178
Peas	34	5.4	0.0– 20
Soybeans	47	45	10 – 151
Spinach	56	29	2.7– 167
Root vegetables (washed, unpeeled)			
Beets	24	17	0.7– 104
Carrots	88	6.0	0.5– 28
Onions	60	4.8	0.5– 26
Potatoes, white	116	2.1	0.0– 11
Potatoes, sweet	20	19	4.4– 44
Radishes	19	10	1.1– 51
Turnips	25	12	0.5– 65
Fruits			
Apples	60	1.0	0.0– 2.8
Avocado	6	1.4	0.1– 4.7
Banana	7	0.2	0.1– 0.5
Blueberries	9	10	5.7– 24
Cantaloupes	4	1.4	0.5– 3.4
Cherries	19	6.6	3.4– 9.8
Cranberries	9	37	3.6– 110
Cucumbers	10	3.3	0.8– 8.3
Dates	6	3.4	0.6– 8.7
Figs	14	7.5	2.1– 9.5
Grapes	6	5.2	0.9– 7.9
Grapefruit	5	1.4	0.8– 1.7
Lemon	5	1.1	0.5– 1.8
Olives	5	5.1	2.3– 12
Orange	9	2.1	0.8– 4.7
Peaches	33	1.8	0.4– 12
Pears	4	1.2	0.1– 3.2
Peppers	14	2.3	0.0– 11
Pumpkin	17	7.3	0.5– 26
Raisins	8	3.5	0.0– 8.8
Squash	31	6.7	0.9– 23
Strawberries	46	13	0.9– 37
Tomatoes	83	1.5	0.1– 9.9
Grain			
Barley	36	16	0.5– 69
Corn	48	1.5	0.0– 8.8
Oats	30	31	4.8– 166
Rice	11	3.7	0.2– 8.3
Rye	19	25	6.5– 112
Wheat	150	19	0.9– 108
Dairy Products			
Egg substance	19	1.9	0.4– 3.5
Cheese	55	52	11 – 416
Milk, evaporated	26	16	2.1– 64
Sea Food			
Clams	13	0.9	0.0– 4.6
Crabmeat	4	5.1	4.2– 5.8
Haddock	8	0.5	0.1– 2.1
Lobster	9	0.5	0.0– 1.5
Oysters	23	1.1	0.0– 9.8
Salmon	6	0.6	0.0– 1.4
Sardines	36	1.8	0.0– 8.1
Shrimp	20	0.9	0.0– 3.3
Tuna fish	42	0.3	0.0– 1.7
Beverage products			
Cocoa beans	31	14	7.3– 25
Coffee	94	17	1.8– 48
Tea	137	387	19 –1630
Nuts			
Almonds	8	7.6	0.7– 19
Brazil nuts	9	63	18 – 119
Cashews	15	1.7	0.0– 4.0
Peanuts	22	37	6.8– 81
Pecans	19	15	3.2– 50
Walnuts	9	2.7	0.0– 9.3
Spices			
Caraway seed	6	109	62 – 206
Cardamom	2	161	98 – 223
Cassia	11	260	4.9–2590
Chili peppers	10	22	1.9– 88
Cinnamon	3	1176	531 –1676
Ginger	1	94	
Hops	3	53	50 – 56
Mustard seed	13	50	17 – 96
Sage leaves	1	618	
Thyme leaves	1	885	

TABLE 3.—GEOGRAPHICAL AND TEMPORAL DISTRIBUTION OF STRONTIUM-90

[pc/kg]

Food	Pre-testing averages[a]			Post-testing averages[a]		
	West	Central	East	West	Central	East
Apples	[b]0.5 (8)		1.0 (10)	0.5 (11)		1.2 (15)
Beans, snap	5.1 (11)	28 (19)	24 (20)			
Carrots	2.7 (14)		4.8 (8)			
Lettuce	2.2 (17)			21 (19)		
Tomatoes	0.9 (9)		2.3 (7)	0.9 (7)		3.1 (6)
Wheat	7.8 (10)	18 (12)	28 (13)	10 (10)	18 (8)	28 (4)

[a] Samples harvested before September 15, 1961, are designated as pre-test, and those harvested after September 15, 1961 are designated as post-test.

[b] Numbers in parentheses refer to number of samples.

Geographical and Temporal Distributions of Strontium–90: In table 3, evidence is presented to show the relation of geographical location and the resumption of nuclear tests to the strontium–90 content of foods.

Apples: A trend toward higher values in the east is evident. However, the influence of weapons testing cannot be demonstrated in either eastern or western samples.

Beans, snap: There is a clear indication that the far western growing areas produced snap beans that had significantly lower concentrations of strontium–90 than those produced in central and eastern sections, at least before resumption of nuclear weapons testing in September 1961.

Carrots: A trend towards higher values in eastern samples is indicated.

Lettuce: Influence of U.S.S.R. testing seems demonstrated in lettuce harvested after September 15, 1961.

Tomatoes: Findings on this fruit essentially confirm those made on apples.

Wheat: While there is no clear–cut evidence of debris from recent nuclear weapons testing, the difference between west, central and eastern wheat is striking.

Cesium–137 in Individual Foods: Surveillance of foods for cesium–137 has been limited to about 10 percent of samples assayed for strontium–90. Table 4 shows a representative set of data from individual samples by which the concentrations of cesium–137 and strontium–90 can be compared. On the average there is more cesium–137 in the samples than strontium–90; this has been reported earlier (*3*).

TABLE 4.—CESIUM–137 AND STRONTIUM–90 IN SELECTED INDIVIDUAL RAW FOODS

Item	Cesium–137 (pc/kg)	Strontium–90 (pc/kg)	Cs^{137}/Sr^{90}
Beans, snap	4.5	22	0.2
Cabbage	56	12	4.7
Egg:			
substance	1.7	1.1	1.5
shell	140	390	0.4
Peaches	<2	1.2	<1.7
Potatoes	<6	3	<2
Soybean flour	336	25	13.4
Spinach			
fresh	68	32	2.1
frozen	29	15	1.9
Tomatoes	33	2.6	12.7
Wheat	58	28	2.1

Iodine–131: The Public Health Service Radiation Surveillance Network recorded peaks of total beta particulates in air in the Salt Lake City area on July 8 and 16, 1962. Alerted by these findings, the FDA, through its inspection staff, collected 4 series of leaf lettuce and endive samples from farms in the area on July 13, 18, 27, and August 6. Whenever possible, the consecutive samples all came from the same farm.*

Analyses were made for iodine–131 and total gamma with the 400–channel gamma spectrometer in the Washington laboratories, while total beta and strontium–90 analyses were made at the Denver District laboratories.

**Editors note: For a detailed discussion, see the article entitled, "Iodine–131 in Milk and Vegetables Associated with July 1962 Fallout in Utah," in Section V of this issue.*

SUMMARY

With respect to the quantities of strontium–90 discovered in these surveys the following orientation ranges can be stated: quantities of strontium–90 of the order of 1 picocurie or less per kilogram are merely of academic interest and indicate the "absence" of strontium–90 within the usually accepted standards for sensitivity and accuracy of strontium–90 methods. Quantities of strontium–90 ranging from 1 to 5 pc/kg are considered "low" and of little consequence. In fact, it can be said that food products carrying such amounts should not be considered "active" vectors that receive appreciable transfer of this isotope either through the soil or from fallout in the air. Quantities of strontium–90 ranging from 5 to 20 pc/kg indicate "active" contamination from soil or air. Such levels are hardly likely to contribute significantly to the total daily intake of this isotope. Quantities of the order of 20 to 100 pc/kg of strontium–90 are potentially significant contributors to the total daily intake, i.e., conceivably as much as 50 percent, depending on the average amount of the food eaten. Quantities of the order of 100 pc/kg of strontium–90 or over deserve constant surveillance and are in fact the criteria that could signal various types of corrective action.

Previous coverage in *Radiological Realth Data*:

Period	Issue
1958 and 1959	*May 1960*
1958, 1959, and 1960	*January 1961*
1960	*August 1961*
1959 and 1960	*September 1961*
1958, 1959, 1960, and 1961	*December 1961*
1960 and 1961	*April 1962*
1961	*June 1962*
1960, 1961, and 1962	*August 1962*
1960, 1961, and 1962	*September 1962*

REFERENCES

(*1*) U.S. Atomic Energy Commission: *HASL Manual of Standard Procedures, NYO–4700*, Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (February 1960), price $1.75.

(*2*) Food and Drug Administration: Strontium–90 in Raw and Processed Foods, *Radiological Health Data* *3*:320–33 (September 1962).

(*3*) Food and Drug Administration: Survey of Radioactivity in Food, *Radiological Health Data*, *2*:515–8 (December 1961).

SECTION III.—MILK

Radionuclide Analyses of Pasteurized Milk

PASTEURIZED MILK NETWORK
August 1962

Division of Radiological Health
Division of Environmental Engineering and Food Protection
Public Health Service

In recognition of the importance of milk as a dietary component, the Public Health Service conducts a continuous monitoring program for radionuclides in pasteurized milk. Milk lends itself readily to a national sampling program because of its widespread and continuous availability and its ease of preparation and analysis compared to other foods.

In 1957 the PHS initiated the investigation of raw milk to determine relationships between dairy practices and radionuclide levels in milk. However, it became evident that the milk actually consumed by the population should be included in a broader sampling program. In 1960, the pasteurized milk network was initiated to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in pasteurized milk monitoring. Since June 1961, raw milk sampling has been carried out for investigative rather than monitoring purposes.

During August 1962, pasteurized milk surveillance was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies who have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis. Publication in *RHD* follows 3 to 4 months after sample collection because of the time required for shipment, processing, radioanalysis of strontium, data compilation, and publication procedures.

Sampling and Compositing Procedures

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all States and additional points when indicated by widely varying conditions of the milk supply or when needed in order to cover large population groups. Each sample is composited from subsamples collected from each plant in proportion to the relative volumes

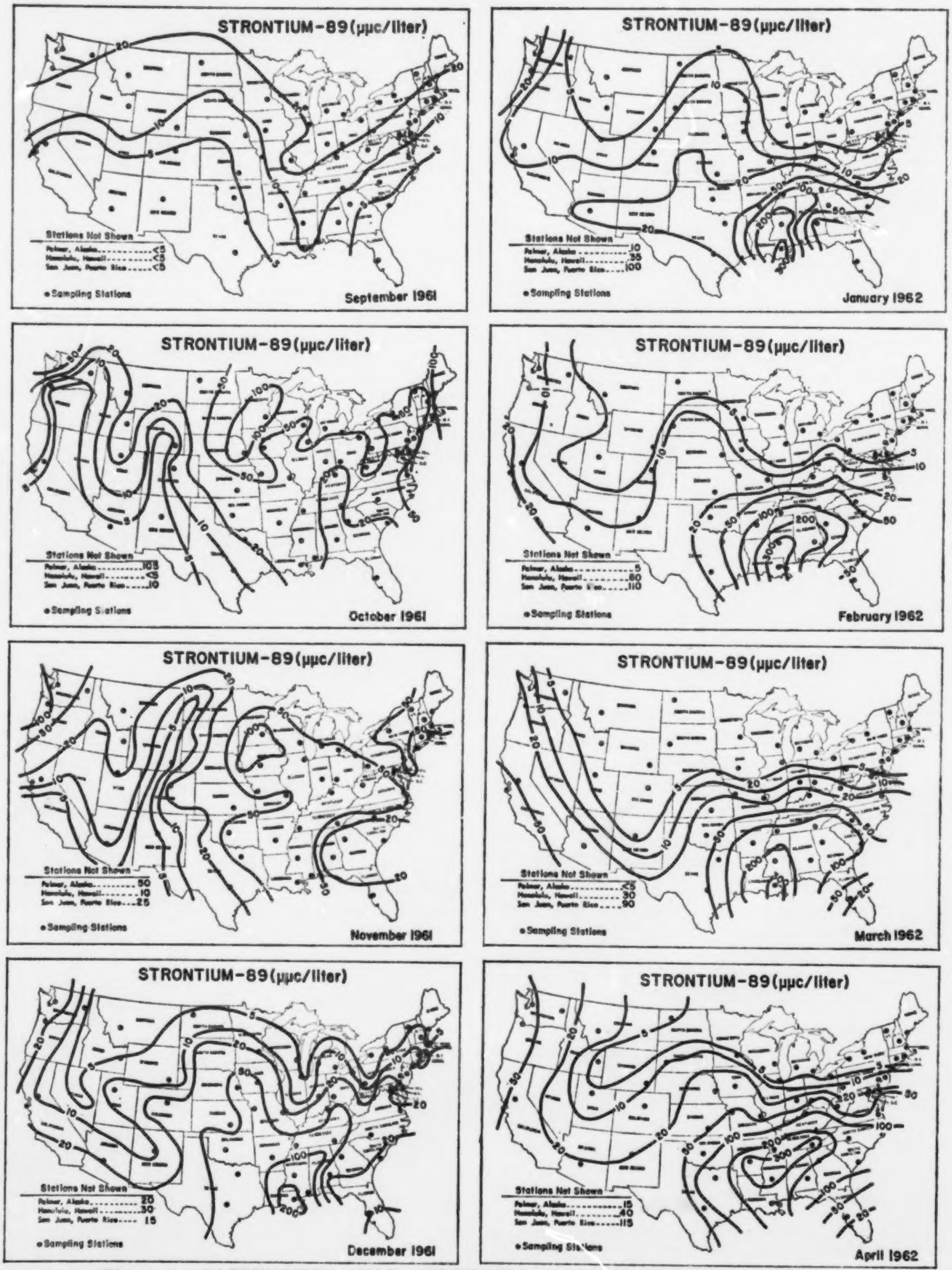
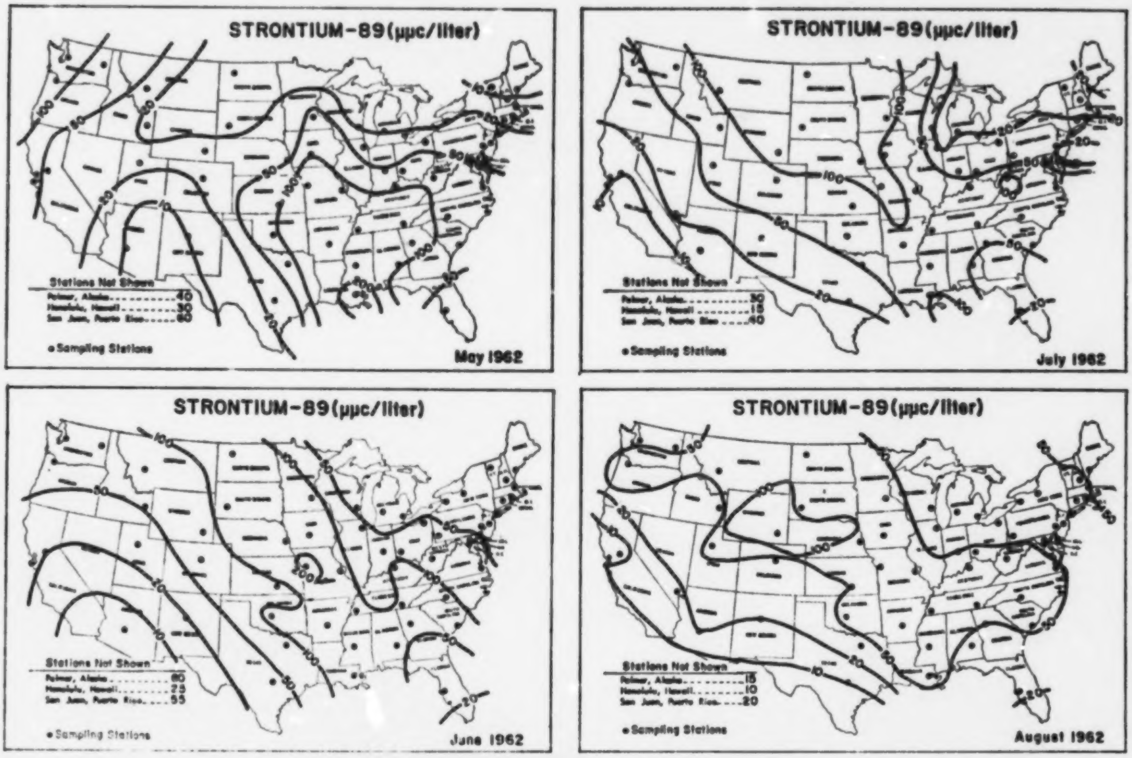

STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska .... <5
Honolulu, Hawaii .... <5
San Juan, Puerto Rico .... <5
• Sampling Stations
September 1961
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii 35
San Juan, Puerto Rico 100
• Sampling Stations
January 1962
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 105
Honolulu, Hawaii .... <5
San Juan, Puerto Rico 10
• Sampling Stations
October 1961
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 5
Honolulu, Hawaii 80
San Juan, Puerto Rico 110
• Sampling Stations
February 1962
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 50
Honolulu, Hawaii 10
San Juan, Puerto Rico 25
• Sampling Stations
November 1961
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska .... <5
Honolulu, Hawaii 30
San Juan, Puerto Rico 90
• Sampling Stations
March 1962
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 20
Honolulu, Hawaii 30
San Juan, Puerto Rico 15
• Sampling Stations
December 1961
STRONTIUM-89 (μμc/liter)
Stations Not Shown
Palmer, Alaska 15
Honolulu, Hawaii 40
San Juan, Puerto Rico 115
• Sampling Stations
April 1962

Figure 1.—PASTEURIZED MILK STRONTIUM-89 CONCENTRATION CONTOURS


STRONTIUM-89 (μμc/liter)

May 1962

STRONTIUM-89 (μμc/liter)

July 1962

STRONTIUM-89 (μμc/liter)

June 1962

STRONTIUM-89 (μμc/liter)

August 1962

Stations Not Shown
Palmer, Alaska 40
Honolulu, Hawaii 30
San Juan, Puerto Rico 60
• Sampling Stations
Stations Not Shown
Palmer, Alaska 30
Honolulu, Hawaii 15
San Juan, Puerto Rico 40
• Sampling Stations
Stations Not Shown
Palmer, Alaska 60
Honolulu, Hawaii 25
San Juan, Puerto Rico 55
• Sampling Stations
Stations Not Shown
Palmer, Alaska 15
Honolulu, Hawaii 10
San Juan, Puerto Rico 20
• Sampling Stations

Figure 1.—PASTEURIZED MILK STRONTIUM-89 CONCENTRATION CONTOURS—Continued

of milk sold. While not confirmed for all stations, the objective of this sampling program is to reflect at least 90 percent of each city's milk supply. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling schedule has been increased in frequency. During August 1962, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Iodine-131, cesium-137, and barium-140 are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 are determined following radiochemical separation. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for August 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Geographical Distribution of Radionuclides

Figure 1 geographically displays the monthly average strontium-89 concentrations in pasteurized milk from September 1961 through August 1962. The concentrations generally were below 200 μμc/liter over the entire country from September 1961 through August 1962. However, several sampling stations in the Mississippi Valley at times had concentrations greater than 200 μμc/liter during the period December 1961 through June 1962.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

Figure 2 shows the strontium–90 monthly average concentration contours for pasteurized milk for August 1962. The November 1962 issue of *RHD* contained strontium–90 contour maps for September 1961 through July 1962. These maps show that from September through December 1961 all stations reported below 20 μμc/liter of strontium–90. From January through March 1962 concentrations of strontium–90 in milk rose to over 20 μμc/liter in the Arkansas–Louisiana–Mississippi area. Concentrations greater than 30 μμc/liter were observed in this same area from April through July 1962. During June 1962, North Dakota and South Dakota also showed concentrations greater than 30 μμc/liter. The concentrations for July 1962 in this region were somewhat lower (approximately 20 μμc/liter) however. The lower Mississippi Valley region as well as several South Atlantic States had strontium–90 concentrations slightly in excess of 20 μμc/liter for the month of August.

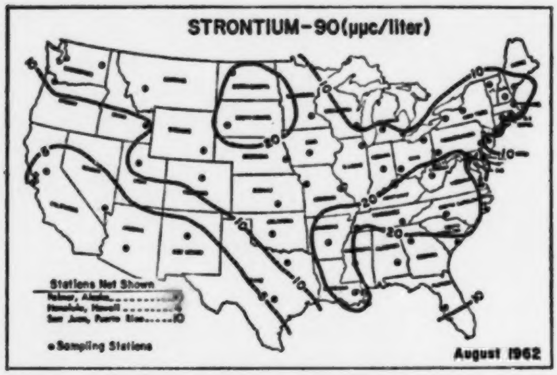

Figure 2.—PASTEURIZED MILK STRONTIUM–90 CONCENTRATION CONTOUR

Figure 3 displays average iodine–131 milk concentration contours for August 1962. The October 1962 issue of *RHD* presents iodine–131 contour maps for the period September 1961 through June 1962. Prior to September 1961 the concentrations of iodine–131 in milk were generally non–detectable (< 10 μμc/liter). From September through November 1961 concentrations greater than 200 μμc/liter appeared at several stations in States bordering the Mississippi River. The levels declined in December 1961. From January through April 1962, iodine–131 concentrations in milk were generally below 20 μμc/liter. Concentrations greater than 200 μμc/liter were seen in various areas in the succeeding months. Concentrations of at least 200 μμc/liter were observed in Kansas and Missouri in May and June 1962. Also, in June 1962, a high of 350 μμc/liter appeared in Spokane, Washington. The greatest July 1962 average (580 μμc/liter) occurred at Salt Lake City, Utah. Concentrati[illegible]r than 200 μμc/liter occurred in [illegible]ing–Utah area in August 1962.

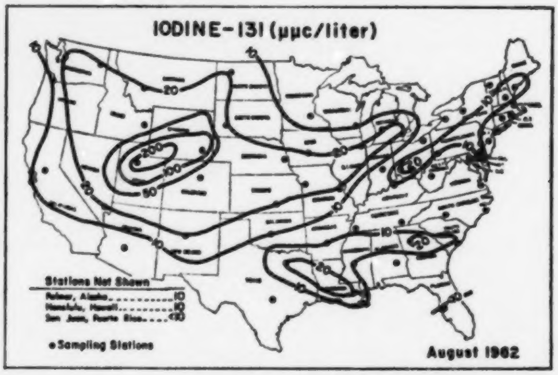

Figure 3.—PASTEURIZED MILK IODINE–131 CONCENTRATION CONTOUR

Selected Monthly Strontium Profiles

In previous issues of *RHD*, the monthly average strontium–90 concentrations in pasteurized milk from selected cities in the monitoring program were published. Profiles for an additional 16 cities are presented in figure 4. These graphs show the strontium–90 concentrations in milk from selected cities in the United States Department of Agriculture marketing regions of the United States.

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TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, AUGUST 1962

[Average radioactivity concentrations in $\mu\mu c$/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Last Sr^{90} profile in RHD
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	
Ala:	Montgomery	1.20	1.22	105	40	19	12	10	<10	55	35	20	<10	Oct. 62
Alaska:	Palmer	1.08	1.05	35	15	9	10	10	10	20	40	<10	<10	Nov. 62
Ariz:	Phoenix	1.09	1.06	15	20	3	2	<10	<10	10	20	<10	<10	Sep. 62
Ark:	Little Rock	1.17	1.21	225	85	37	27	20	10	95	50	40	20	Nov. 62
Calif:	Sacramento	1.09	1.06	30	5	5	2	10	20	15	25	<10	20	Dec. 62
	San Francisco	1.11	1.09	55	10	9	4	<10	<10	15	20	10	<10	Oct. 62
Colo:	Denver	1.16	1.10	30	40	8	14	<10	30	10	80	<10	<10	Dec. 62
Conn:	Hartford	1.19	1.02	15	30	11	10	<10	<10	35	80	<10	<10	Dec. 62
Del:	Wilmington	1.20	1.06	50	45	15	12	10	10	50	85	<10	<10	Sep. 62
D. C:	Washington	1.15	1.14	50	45	15	16	<10	<10	40	65	10	<10	Oct. 62
Fla:	Tampa	1.21	1.22	25	25	10	11	<10	<10	105	150	<10	<10	Sep. 62
Ga:	Atlanta	1.20	1.21	120	50	22	18	<10	20	80	55	20	<10	Oct. 62
Hawaii:	Honolulu	1.08	1.05	30	10	5	4	<10	10	25	40	<10	<10	Nov. 62
Idaho:	Idaho Falls	1.09	1.04	25	40	7	9	10	30	20	70	10	10	Sep. 62
Ill:	Chicago	1.16	1.10	35	40	11	14	20	20	30	65	10	<10	Oct. 62
Ind:	Indianapolis	1.20	1.12	50	50	15	12	20	<10	40	45	20	<10	Dec. 62
Iowa:	Des Moines	1.08	1.08	95	75	15	15	60	20	25	45	20	20	Sep. 62
Kans:	Wichita	1.08	1.07	65	50	12	13	120	20	20	40	20	<10	Nov. 62
Ky:	Louisville	1.17	1.19	115	80	21	20	20	10	40	35	20	10	Sep. 62
La:	New Orleans	1.23	1.22	215	75	37	27	<10	20	135	75	30	20	Nov. 62
Maine:	Portland	1.22	1.16	20	55	12	14	<10	20	50	130	<10	<10	Sep. 62
Md:	Baltimore	1.17	1.16	45	40	15	20	10	<10	50	70	10	<10	Sep. 62
Mass:	Boston	1.16	1.10	20	50	13	19	<10	10	50	145	<10	<10	Oct. 62
Mich:	Detroit	1.17	1.06	25	30	11	10	<10	20	30	80	<10	<10	Dec. 62
	Grand Rapids	1.23	1.12	20	35	10	11	<10	20	30	65	<10	<10	Sep. 62
Minn:	Minneapolis	1.08	1.06	60	60	13	19	50	<10	30	105	10	<10	Oct. 62
Miss:	Jackson	1.26	1.26	220	80	33	20	<10	10	85	45	30	20	Dec. 62
Mo:	Kansas City	1.09	1.05	130	80	18	14	150	30	30	30	40	10	Dec. 62
	St. Louis	1.08	1.04	85	55	16	16	30	20	30	40	10	10	Nov. 62
Mont:	Helena	1.08	1.11	45	60	10	12	20	20	25	80	10	10	Nov. 62
Nebr:	Omaha	1.13	1.07	65	85	13	12	40	40	20	50	10	20	Sep. 62
Nev:	Las Vegas*		1.04		15		3		20		45		<10	
N. H:	Manchester	1.15	1.16	15	45	10	17	<10	20	60	155	<10	<10	Sep. 62
N. J:	Trenton	1.13	1.11	25	35	10	9	<10	<10	30	70	<10	<10	Dec. 62
N. Mex:	Albuquerque	1.09	1.07	15	20	4	3	10	20	<5	25	10	<10	Nov. 62
N. Y:	Buffalo	1.16	1.11	20	30	10	16	<10	<10	40	80	<10	<10	Dec. 62
	New York	1.13	1.03	20	40	12	14	10	<10	40	95	<10	<10	Oct. 62
	Syracuse	1.17	1.12	20	40	10	13	20	<10	25	70	<10	<10	Nov. 62
N. C:	Charlotte	1.22	1.21	95	55	22	23	<10	<10	55	50	20	10	Nov. 62
N. Dak:	Minot	1.10	1.11	60	70	16	21	20	20	30	75	<10	10	Sep. 62
Ohio:	Cincinnati	1.18	1.12	65	55	17	14	20	20	30	40	20	<10	Dec. 62
	Cleveland	1.15	1.12	35	30	11	12	<10	<10	30	55	<10	<10	Nov. 62
Okla:	Oklahoma City	1.15	1.15	115	60	21	14	60	10	60	30	30	10	Oct. 62
Ore:	Portland	1.13	1.08	95	130	17	12	10	10	55	70	10	<10	Dec. 62
Pa:	Philadelphia	1.16	1.14	35	40	13	10	<10	10	45	75	<10	<10	Nov. 62
	Pittsburgh	1.17	1.14	35	45	14	19	10	10	45	90	<10	<10	Nov. 62
P. R:	San Juan	1.13	1.18	75	20	11	10	20	<10	55	40	20	<10	Nov. 62
R. I:	Providence	1.19	1.11	20	40	12	13	10	<10	45	95	<10	<10	Sep. 62
S. C:	Charleston	1.20	1.20	95	55	21	19	<10	10	75	60	20	<10	Dec. 62
S. Dak:	Rapid City	1.09	1.07	70	90	17	27	<10	20	30	90	10	10	Oct. 62
Tenn:	Chattanooga	1.24	1.24	200	75	28	24	10	<10	90	50	30	10	Oct. 62
	Memphis	1.21	1.22	160	50	27	20	<10	<10	40	25	30	<10	Sep. 62
Tex:	Austin	1.17	1.16	35	10	8	6	<10	<10	25	15	<10	<10	Oct. 62
	Dallas	1.18	1.16	115	40	18	11	20	20	50	30	20	<10	Dec. 62
Utah:	Salt Lake City	1.11	1.06	25	80	8	13	<10	330	30	95	<10	30	Nov. 62
Vt:	Burlington	1.13	1.05	15	50	10	13	<10	<10	30	125	<10	<10	Dec. 62
Va:	Norfolk	1.19	1.19	70	55	17	19	<10	<10	55	70	10	<10	Dec. 62
Wash:	Seattle	1.12	1.08	80	40	18	14	<10	20	55	95	<10	<10	Oct. 62
	Spokane	1.15	1.16	60	35	14	14	120	20	35	75	<10	<10	Dec. 62
W. Va:	Charleston	1.17	1.15	80	85	18	26	20	<10	35	45	20	10	Oct. 62
Wis:	Milwaukee	1.20	1.11	15	25	8	10	10	10	15	65	<10	<10	Sep. 62
Wyo:	Laramie	1.10	1.08	30	150	8	15	20	160	25	100	10	30	Sep. 62
Network average		1.15	1.12	64	50	14.4	14.1	19	20	42	65	12	8	

* The Las Vegas station entered the network in July 1962.

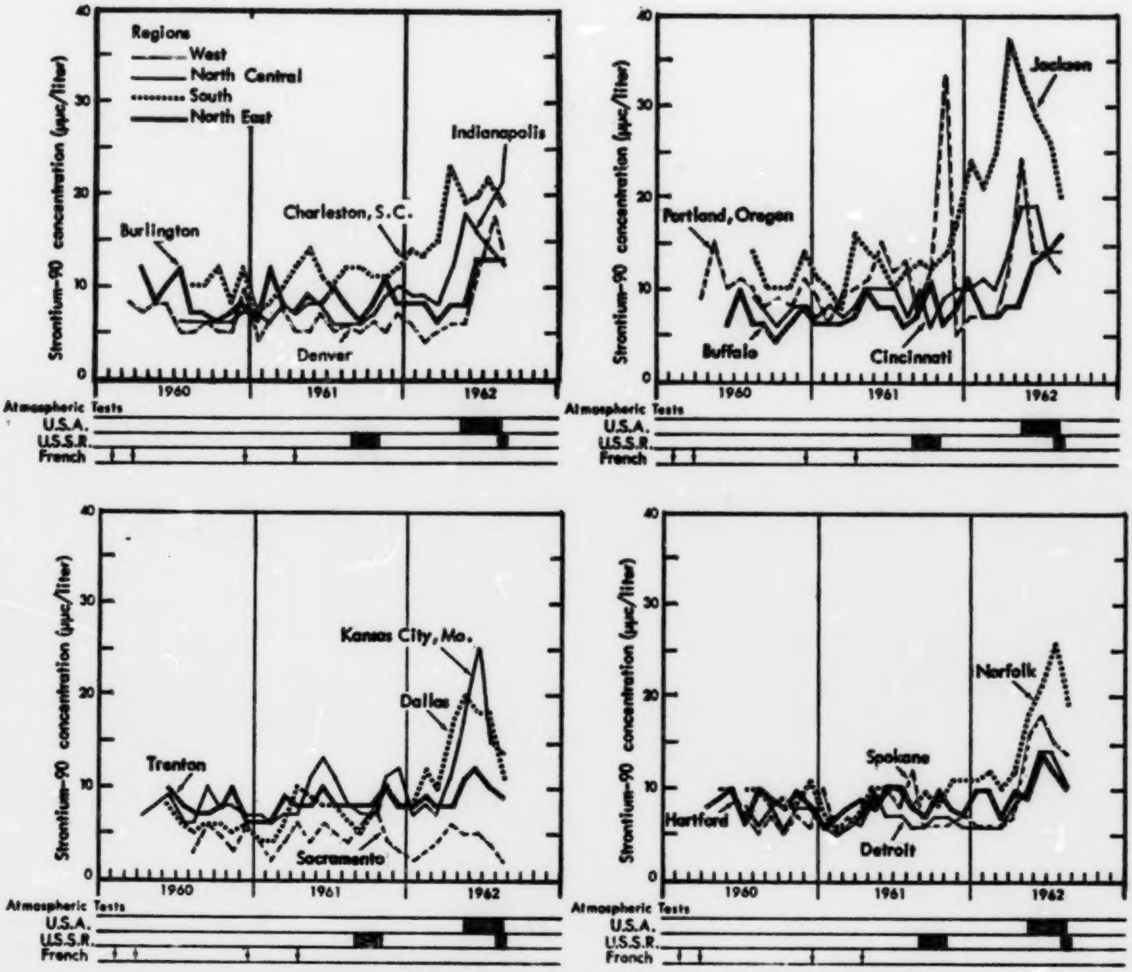

Figure 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TWELVE-MONTH SUM OF DAILY RADIONUCLIDE CONTENT OF ONE LITER OF PASTEURIZED MILK

October 1961—September 1962: Iodine–131
September 1961—August 1962: Strontium–90

Division of Radiological Health,
Public Health Service

The guidance of the Federal Radiation Council is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The ranges are based on radiation doses considered acceptable for lifetime exposure from normal peacetime operations. The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures (*1, 2*).

To facilitate comparison of the concentration of certain radionuclides in milk with the Radiation Protection Guides, tables 2 and 3 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine–131 and strontium–90 respectively. The tables are based on the same data which are used for computing the Pasteurized Milk Network monthly averages. They present index values which are the sum of the daily amounts of a radionuclide in one liter of milk for a 12 month period.

The tables show 12-month index values for

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

Sampling locations		Sep. 1962 iodine-131 averages (μμc/liter)	Iodine-131 index values (μμc day/liter)[a]			
			Sep. 1961—Aug. 1962	Sep. 1961[b]	Aug. 26, 1962—Sep. 29, 1962	Oct. 1961—Sep. 1962
Ala:	Montgomery	20	4,650	900	700	4,450
Alaska:	Palmer	730	24,010	9,900	25,550	39,660
Ariz:	Phoenix	10	8,460	1,800	350	7,010
Ark:	Little Rock	20	14,860	3,600	700	11,960
Calif:	Sacramento	<10	4,760	300	180	4,640
	San Francisco	20	4,590	600	700	4,690
Colo.	Denver	20	9,670	1,800	700	8,570
Conn:	Hartford	70	6,230	1,800	2,450	6,880
Del:	Wilmington	70	7,620	1,800	2,450	8,270
D. C:	Washington	60	5,640	1,200	2,100	6,540
Fla:	Tampa	<10	5,630	1,200	180	4,610
Ga:	Atlanta	10	9,190	2,400	350	7,140
Hawaii:	Honolulu	10	4,440	600	350	4,190
Idaho:	Idaho Falls	40	16,470	4,200	1,400	13,670
Ill:	Chicago	100	14,660	3,300	3,500	14,860
Ind:	Indianapolis	70	9,010	2,100	2,450	9,360
Iowa:	Des Moines	120	32,750	8,700	4,200	28,250
Kans:	Wichita	30	26,740	3,900	1,050	23,890
Ky:	Louisville	40	10,790	2,700	1,400	9,490
La:	New Orleans	<10	9,840	2,700	180	7,320
Maine:	Portland	60	7,310	600	2,100	8,810
Md:	Baltimore	60	7,100	2,100	2,100	7,100
Mass:	Boston	70	10,950	3,900	2,450	9,500
Mich:	Detroit	120	17,850	6,300	4,200	15,750
	Grand Rapids	70	9,660	2,700	2,450	9,410
Minn:	Minneapolis	100	32,060	10,200	3,500	25,360
Miss:	Jackson	<10	12,570	4,500	180	8,250
Mo:	Kansas City	60	33,650	4,500	2,100	31,250
	St. Louis	50	19,060	5,400	1,750	15,410
Mont:	Helena	90	17,950	4,800	3,150	16,300
Nebr:	Omaha	80	27,720	7,500	2,800	23,020
Nev:	Las Vegas[c]	20	2,240	[d]—	700	2,940
N. H:	Manchester	60	9,220	3,000	2,100	8,320
N. J:	Trenton	50	7,890	2,700	1,750	6,940
N. Mex:	Alberquerque	20	7,420	900	700	7,220
N. Y:	Buffalo	100	8,650	3,000	3,500	9,150
	New York	90	10,590	4,200	3,150	9,540
	Syracuse	90	12,160	4,200	3,150	11,110
N. C:	Charlotte	<10	4,570	1,200	180	3,550
N. Dak:	Minot	170	9,990	900	5,950	15,040
Ohio:	Cincinnati	80	12,380	3,000	2,800	12,180
	Cleveland	90	9,270	3,000	3,150	9,420
Okla:	Oklahoma City	20	19,130	2,700	700	17,130
Ore:	Portland	30	11,980	1,800	1,050	11,230
Pa:	Philadelphia	60	8,170	2,400	2,100	7,870
	Pittsburgh	70	9,180	2,700	2,450	8,930
P. R:	San Juan	<10	4,890	600	180	4,470
R. I:	Providence	50	8,330	2,400	1,750	7,680
S. C:	Charleston	10	7,230	2,770	350	4,810
S. Dak:	Rapid City[e]	130	3,400	—	4,550	7,950
Tenn:	Chattanooga	20	8,630	2,400	700	8,930
	Memphis	20	14,910	4,800	700	10,810
Tex:	Austin	<10	5,150	600	180	4,730
	Dallas	<10	8,060	600	180	7,640
Utah:	Salt Lake City	40	37,040	4,200	1,400	34,240
Vt:	Burlington	60	9,100	3,000	2,100	8,200
Va:	Norfolk	20	7,600	2,400	700	5,900
Wash:	Seattle	30	11,280	300	1,050	12,030
	Spokane	60	25,590	3,600	2,100	24,090
W. Va:	Charleston	30	6,700	1,800	1,050	5,950
Wis:	Milwaukee	120	14,410	4,500	4,200	14,110
Wyo:	Laramie	40	20,790	1,200	1,400	20,990

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual I^{131} intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index X milk consumption factor = 12-month I^{131} intake.
(μμc day/liter) (liter/day/person) (μμc/person)

[b] Index values for stations for which September 1961 data were not available include an estimate for that month based on the October 1961 values.

[c] Station began operation in July 1962; total is for 3 months.

[d] Dash indicates no data available.

[e] Station began operation in January 1962; total is for 9 months.

each of the Network's 62 sampling locations. The first column in each table shows the monthly radionuclide averages. The second column consists of 12-month index values. Due to the longer time required for strontium-90 analysis, the 12-month index values for this radionuclide are for the year beginning one month earlier than the iodine-131 values. The

TABLE 3.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Aug 1962 Strontium-90 averages (μμc/liter)	Strontium-90 index values (μμc day/liter)[a]			
			Aug. 1961—July 1962	Aug. 1961	July 29, 1962—Aug. 25, 1962	Sep. 1961—Aug. 1962
Ala:	Montgomery[b]	12	3,751	[c]—	336	4,087
Alaska:	Palmer	10	3,170	217	280	3,233
Ariz:	Phoenix	2	1,360	124	56	1,292
Ark:	Little Rock	27	8,630	496	756	8,890
Calif:	Sacramento	2	1,638	124	56	1,570
	San Francisco	4	1,887	155	112	1,844
Colo:	Denver	14	2,633	186	392	2,839
Conn:	Hartford	10	3,378	248	280	3,410
Del:	Wilmington	12	4,225	372	336	4,189
D. C:	Washington	16	3,706	217	448	3,937
Fla:	Tampa	11	2,678	155	308	2,831
Ga:	Atlanta	18	5,407	310	504	5,601
Hawaii:	Honolulu	4	1,988	186	112	1,914
Idaho:	Idaho Falls	9	2,233	186	252	2,299
Ill:	Chicago	14	2,848	124	392	3,116
Ind:	Indianapolis	12	3,730	186	336	3,880
Iowa:	Des Moines	15	3,779	186	420	4,013
Kans:	Wichita	13	3,613	217	364	3,760
Ky:	Louisville	20	5,088	248	560	5,400
La:	New Orleans	27	9,142	434	756	9,464
Maine:	Portland	14	4,122	310	392	4,204
Md:	Baltimore	20	3,895	310	560	4,145
Mass:	Boston	19	4,171	279	532	4,424
Mich:	Detroit	10	2,905	186	280	2,999
	Grand Rapids	11	2,994	186	308	3,116
Minn:	Minneapolis	19	4,156	341	532	4,347
Miss:	Jackson	20	7,895	372	560	8,083
Mo:	Kansas City	14	4,114	248	392	4,258
	St. Louis	16	4,045	186	448	4,307
Mont:	Helena	12	2,921	124	336	3,133
Nebr:	Omaha	12	3,789	279	336	3,846
Nev:	Las Vegas[d]	3	168	—	84	252
N. H:	Manchester	17	3,980	310	476	4,146
N. J:	Trenton	9	3,264	248	252	3,268
N. Mex:	Alberquerque	3	1,666	155	84	1,595
N. Y:	Buffalo	16	3,198	186	448	3,460
	New York	14	3,635	186	392	3,841
	Syracuse	13	2,843	186	364	3,021
N. C:	Charlotte	23	5,511	403	644	5,752
N. Dak:	Minot[e]	21	4,168	—	588	4,756
Ohio:	Cincinnati	14	4,192	217	392	4,367
	Cleveland	12	3,238	248	336	3,326
Okla:	Oklahoma City	14	4,457	186	392	4,663
Ore:	Portland	12	4,649	403	336	4,582
Pa:	Philadelphia	10	3,588	279	280	3,589
	Pittsburgh	19	4,154	310	532	4,376
P. R:	San Juan	10	2,844	124	280	3,000
R. I:	Providence	13	3,778	403	364	3,739
S. C:	Charleston	19	5,534	372	532	5,694
S. Dak:	Rapid City[f]	27	2,836	—	756	3,592
Tenn:	Chattanooga	24	6,502	372	672	6,802
	Memphis	20	6,280	372	560	6,468
Tex:	Austin	6	2,027	62	168	2,133
	Dallas	11	4,204	186	308	4,326
Utah:	Salt Lake City	13	2,252	124	364	2,492
Vt:	Burlington	13	3,171	248	364	3,287
Va:	Norfolk	19	4,753	248	532	5,037
Wash:	Seattle	14	4,348	248	392	4,492
	Spokane	14	3,369	372	392	3,389
W. Va:	Charleston	26	4,762	310	728	5,180
Wis:	Milwaukee	10	2,427	124	280	2,583
Wyo:	Laramie	15	2,501	155	420	2,766

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month Sr^{90} index X milk consumption factor = 12-month Sr^{90} intake.
(μμc day/liter) (liter/day/person) (μμc/person)

[b] The station began operation in October 1961.

[c] Dash indicates no data available.

[d] The station began operation in July 1962.

[e] The station began operation in September 1961.

[f] The station began operation in January 1962.

following two columns in each table are used to compute the net change as the yearly index values are advanced by one month. The last column shows this new 12-month index value.

The data in tables 2 and 3 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and a daily average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the daily average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. Procedures exemplified by (a) and (b) above minimize the effect of any one day's sample results on the average for the month.

For a number of reasons it is desirable to have a standard quantity of milk to use in the development of index values for the different radionuclides. In the case of strontium, 1 liter is a suitable quantity as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. In the case of iodine–131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18 month group is not more than 1 liter per day. Thus the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159–65 (May 1962).

(*2*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

INDIANA MILK NETWORK

August 1962–September 1962

Bureau of Environmental Sanitation
Indiana State Board of Health

In September 1961 the Indiana State Board of Health initiated a program of milk sampling for radiological analyses. Indiana was geographically divided into five major milksheds with one large dairy within each milkshed being selected as a sampling station (see figure 5).

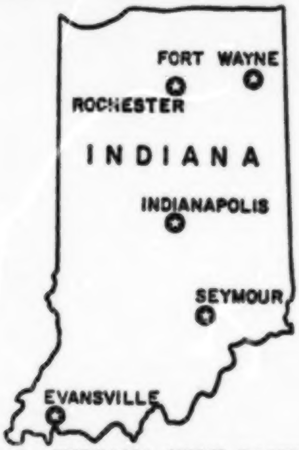

Figure 5.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–lanthanum–140, strontium–89, and strontium–90. Analyses for iodine–131, cesium–137, and barium–lanthanum–140 are conducted on a weekly basis except when iodine–131 results exceed 100 μμc/liter at which time the frequency of sampling is increased. Samples which are analyzed for strontium–89 and strontium–90 are composited weekly and analyzed monthly.

The trichloroacetic acid analytical procedure (*1*) is used for strontium–89 and strontium–90 analyses. A 512–channel pulse height analyzer and shielded 4" x 4" NaI crystal are used for the gamma scintillation analysis of iodine–131, cesium–137, and barium–lanthanum–140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values. There are no strontium–89 and strontium–90 results for August 1962 due to technical difficulties. Strontium–89 and strontium–90 results for September 1962 will be available next month.

TABLE 4.—INDIANA MILK NETWORK, AUGUST 1962—SEPTEMBER 1962

[Concentrations in μμc/liter]

Sampling locations	Iodine–131		Cesium–137		Barium–140	
	Aug 1962	Sept 1962	Aug 1962	Sept 1962	Aug 1962	Sept 1962
Evansville	20	70	30	20	<10	<10
Fort Wayne	20	150	40	40	<10	10
Indianapolis	<10	90	35	30	<10	10
Rochester	10	130	45	40	<10	10
Seymour	20	60	45	35	<10	10
State average	20	100	40	35	<10	10

REFERENCE

(*1*) Robert A. Taft Sanitary Engineering Center: *Radionuclide Analysis of Environmental Samples, Technical Report R59-6:* SS-E-1 (November 16, 1959).

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
June 1962

Division of Water Supply and Pollution Control, Public Health Service

In October 1957 the National Water Quality Network was begun (*1*). This network, operated by the Public Health Service in cooperation with State and local agencies, consisted of 119 stations as of June 30 (see figure 1). These stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. Samples are taken weekly, monthly, or continuously, depending on the type of analysis and the water quality. These samples are analyzed for plankton population, organic chemicals, chemical, biological, and physical quality, and radioactivity (*2, 3*).

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment procedures (*4*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples according to established procedures. (*5, 6*).

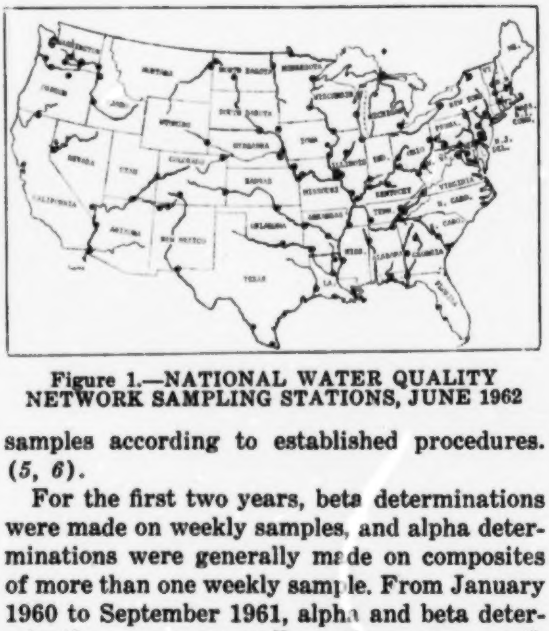

Figure 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, JUNE 1962

For the first two years, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples. Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in μμc/liter]

Station	Quarter ending Dec. 31, 1961	June 1962					
		Beta activity			Alpha activity		
	Total Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	-	1	17	18	—	—	—
Animas River: Cedar Hill, N. Mex.	0.9	10	18	28	2	1	3
Apalachicola River: Chattahoochie, Fla.	—	4	12	16	0	0	0
Arkansas River:							
Coolidge, Kansas	.0	201	119	320	42	14	56
Pendleton Ferry, Ark.	0.5	—	—	—	—	—	—
Ponca City, Okla.	0.6	344	72	416	—	—	—
Big Horn River: Hardin, Mont.	—	165	39	204	43	5	48
Big Sioux River: Sioux Falls, So. Dak.	1.2	38	104	142	2	3	5
Chattahoochie River:							
Atlanta, Ga.	0.3	8	6	14	0	0	0
Columbus, Ga.	—	3	7	10	1	0	1
Chena Slough: Fairbanks, Alaska	—	7	10	17	1	0	1
Clear Water River: East Lewiston, Idaho	0.3	2	9	11	0	0	0
Colorado River:							
Loma, Colo.	—	15	18	33	2	2	4
Page, Ariz.	—	56	14	70	12	3	15
Boulder City, Nev.	1.8	0	20	20	0	6	6
Yuma, Ariz.	—	13	52	65	—	—	—
Columbia River:							
Northport, Wash.	—	6	8	14	0	0	0
Wenatchee, Wash.	0.7	4	8	12	—	—	—
Pasco, Wash.	—	17	93	110	0	0	0
McNary Dam, Oreg.	—	20	56	76	0	1	1
Bonneville, Oreg.	—	28	65	93	—	—	—
Clatskanie, Oreg.	—	35	52	87	—	—	—
Connecticut River:							
Wilder, Vt.	3.7	3	12	15	0	0	0
Northfield, Mass.	0.4	4	10	14	—	—	—
Cumberland River: Clarksville, Tenn.	0.9	—	—	—	—	—	—
Delaware River:							
Martins Creek, Pa.	0.5	7	13	20	—	—	—
Trenton, New Jersey	0.7	—	—	—	—	—	—
Philadelphia, Pa.	—	6	14	20	—	—	—
Escambia River: Century, Fla.	0.5	6	14	20	1	0	1
Great Lakes:							
Duluth, Minn.	0.1	1	7	8	0	0	0
Sault Ste. Marie, Mich.	—	1	8	9	—	—	—
Milwaukee, Wis.	0.8	2	6	8	0	1	1
Gary, Ind.	0.1	6	12	18	0	1	1
Port Huron, Mich.	0.8	3	13	16	—	—	—
Detroit, Mich.	—	2	12	14	—	—	—
Buffalo, N. Y.	0.8	6	13	19	0	1	1
Hudson River: Poughkeepsie, N. Y.	2.5	—	—	—	—	—	—
Illinois River:							
Peoria, Ill.	0.7	5	24	29	—	—	—
Grafton, Ill.	0.6	16	18	34	1	3	4
Kanawha River: Winfield Dam, W. Va.	—	6	14	20	—	—	—
Klamath River: Keno, Oreg.	1.2	2	11	13	—	—	—
Little Miami River: Cincinnati, Ohio	0.6	20	26	46	1	2	3
Mississippi River:							
St. Paul, Minn.	0.6	24	54	78	1	3	4
Dubuque, Iowa	—	4	38	42	—	—	—
Burlington, Iowa	1.9	21	35	56	1	0	1
E. St. Louis, Ill.	—	136	33	169	4	2	6
Cape Giradeau, Mo.	—	257	38	295	56	2	58
W. Memphis, Ark.	—	27	35	62	—	—	—
Delta, La.	1.8	15	31	46	0	2	2
New Orleans, La.	—	24	26	50	—		
Vicksburg, Miss.	—	37	28	65	4	2	6
Missouri River:							
Williston, N. Dak.	1.2	178	34	212	—	—	—
Bismarck, N. Dak.	1.1	33	26	59	0	4	4
Yankton, S. Dak.	2.5	14	36	50	—	—	—
Omaha, Nebr.	0.7	192	55	247	—	—	—
St. Joseph, Mo.	—	426	53	479	—	—	—
Kansas City, Kans.	—	476	41	517	—	—	—
St. Louis, Mo.	2.1	328	42	370	—	—	—
Missouri City, Mo.	—	584	48	632	59	2	61
Monongahela: Pittsburgh, Pa.	1.3	2	44	46	0	2	2
North Platte River: Henry, Nebr.	1.3	26	56	82	2	22	24
Ohio River:							
Addison, Ohio	—	1	15	16	0	0	0
East Liverpool, Ohio	—	1	19	20	0	0	0
Huntington, W. Va.	1.0	23	23	46	0	1	1
Cincinnati, Ohio	—	6	19	25	0	0	0
Louisville, Ky.	—	7	26	33	1	0	1
Evansville, Ind.	—	11	20	31	—	—	—
Cairo, Ill.	—	1	20	21	0	1	1
Ouachita River: Bastrop, La.	0.7	49	43	92	3	1	4
Pend Oreille River: Albeni Fall Dam, Idaho	—	7	8	15	0	<1	<1
Platte River: Plattsmouth, Nebr.	—	344	62	406	23	1	24
Potomac River:							
Williamsport, Md.	0.9	5	13	18	0	0	0
Great Falls, Md.	—	2	17	19	0	0	0

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in μμc/liter]

Station	Quarter ending Dec. 31, 1961	June 1962					
	Total Strontium-90	Beta activity			Alpha activity		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Rainy River:							
Baudette, Minn	—	55	70	125	0	0	0
International Fls, Minn	0.3	8	30	38	0	0	0
Red River, South:							
Denison, Tex	—	16	42	58	1	1	2
Index, Ark	1.7	95	16	111	8	0	8
Alexandria, La	2.7	66	43	109	2	1	3
Rio Grande River:							
Alamosa, Colo	—	6	19	25	0	0	0
El Paso, Tex	—	22	21	43	—	—	—
Laredo, Tex	0.6	50	43	93	—	—	—
Brownsville, Tex	0.6	15	16	31	—	—	—
Roanoke River: John H. Kerr Resr. & Dam, Va	0.6	9	16	25	0	0	0
Sabine River: Ruliff, Tex	—	30	41	71	—	—	—
Sacramento River: Greens Landing, Courtland, Calif	—	16	0	16	1	0	1
San Juan River: Shiprock, N. Mex	—	54	12	66	18	2	20
St. Lawrence River: Massena, N. Y	1.6	4	11	15	—	—	—
Schuylkill River: Philadelphia, Pa	—	4	27	31	—	—	—
Savannah River:							
North Augusta, S. C	—	11	18	29	—	—	—
Port Wentworth, Ga	0.7	15	34	49	0	0	0
Shenandoah River: Berryville, Va	0.2	14	14	28	<1	<1	1
Ship Creek: Anchorage, Alaska	—	2	4	6	0	0	0
Snake River:							
Payette, Idaho	2.5	12	30	42	1	2	3
Wawawai, Wash	—	7	13	20	—	—	—
Ice Harbor Dam, Wash	—	4	15	19	<1	<1	1
Spokane River: Post Falls, Idaho	—	6	4	10	0	0	0
Susquehanna River:							
Sayre, Pa	—	5	12	17	—	—	—
Conowingo, Md	—	6	21	27	—	—	—
Tennessee River:							
Lenoir City, Tenn	—	5	10	15	0	0	0
Chattanooga, Tenn	0.5	0	18	18	0	0	0
Bridgeport, Ala	—	5	26	31	—	—	—
Pickwick Landing, Tenn	—	8	43	51	<1	0	<1
Tombigbee River: Columbus, Miss	0.2	50	26	76	1	0	1
Truckee River: Farad, Calif	0.1	5	21	26	1	0	1
Verdigris River: Nowata, Okla	—	92	57	149	6	2	8
Wabash River: New Harmony, Ind	—	218	34	252	10	0	10
Yakima River: Richland, Wash	0.6	3	10	13	0	<1	<1
Yellowstone River: Sidney, Mont	—	149	8	157	—	—	—

each new station, weekly samples are analyzed for alpha and beta activity.

If at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least one every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*7*).

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(*2*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1960 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

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(*6*) Robert A. Taft Sanitary Engineering Center Public Health Service: *Radionuclide Analysis of Environmental Samples*, Technical Report, R59-6 (1959).

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SECTION V.—OTHER DATA

Whole Body Counting

Whole body counters are being applied where the detection of low levels of radioactivity in the human body is important. One example is the evaluation of hazards to radiation workers and the general population. These instruments are also used in human physiological and pathological investigations as well as in studies related to counter design for special purposes. Discussion and presentation of whole body counting results in previous issues of *RHD* have been limited to medical research programs employing thallium–activated sodium iodide crystals or liquid scintillation solutions. As other whole body counting data become available, they will be published.

CESIUM–137 IN MAN

June 1962 through August 1962
U.S. Army Medical Research Unit, Landstuhl, Germany

In 1955, cesium–137 was first detected in man by the Argonne National Laboratory. It emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium–137 levels are usually expressed in micromicrocuries per gram of potassium. The whole body counting facility at the Medical Research Unit, Landstuhl, Germany, in its program for measuring the cesium–137 levels in man, utilizes a liquid scintillation counter (*1*).

TABLE 1.—ASSAYS PERFORMED AT THE U. S. ARMY MEDICAL RESEARCH UNIT LANDSTUHL, GERMANY

Date	Number of subjects	Residence	Cesium–137 $\mu\mu c$/g K (average)	Percent MPBB*
June 1962	251	West Germany	32	0.15
July 1962	284	West Germany	38	0.18
August 1962	169	West Germany	44	0.20

* Percent maximum permissible body burden was calculated using 3 μc of cesium–137 as the general population maximum permissible whole body burden and 140 grams of potassium in the body of the "standard man." (See pp. 187 and 192 of Radiological Health Handbook, Office of Technical Services, U. S. Department of Commerce (1960), price $3.75.)

Previous coverage in *Radiological Health Data*:

Period	Issue
1958 and 1959	*October 1960*
1959 and 1960	*January 1961*
1958, 1959, and 1960	*April 1961*
First quarter 1961	*July 1961*
Second quarter 1961	*October 1961*
Third quarter 1961	*January 1962*
First quarter 1962	*August 1962*
Second quarter 1962	*October 1962*

REFERENCE

(*1*) *Radiological Health Data*, 2:192–4 (April 1961).

External Gamma Exposure Dose Rate

RADIATION SURVEILLANCE NETWORK
September 1962

Division of Radiological Health, Public Health Service

Daily measurements of external gamma radiation are made at stations of the Radiation Surveillance Network to assure detection of any substantial deviations from normal background levels reported in recent years. Portable Geiger–Mueller survey instruments are used to obtain measurements at three feet above the ground surface. September 1962 data given in table 1 are characteristic of individual station observations during the past several years.

Correction for October issue: External gamma measurement for July 1962 at Lincoln, Nebraska should read 0.01 mr/hr.

TABLE 1.—EXTERNAL GAMMA RADIATION, RSN, SEPTEMBER 1962

Station location		Average (mr/hr)	Station location		Average (mr/hr)
Alaska:	Adak	0.01	Minn:	Minneapolis	0.01
	Anchorage	0.01	Miss:	Jackson	0.01
	Attu	0.01		Pascagoula	—
	Fairbanks	0.01	Mo:	Jefferson City	0.01
	Juneau	0.01	Mont:	Helena	0.03
	Kodiak	0.01	Nebr:	Lincoln	0.01
	Nome	0.01	Nev:	Las Vegas	0.01
	Point Barrow Isl	0.01	N. H:	Concord	—
	St. Paul Island	0.02	N. J:	Trenton	0.02
Ariz:	Phoenix	0.01	N. Mex:	Santa Fe	0.05
Ark:	Little Rock	0.01	N. Y:	Albany	0.02
Calif:	Berkeley	0.01		Buffalo	0.01
	Los Angeles	0.02		New York	—
Colo:	Denver	0.02	N. C:	Gastonia	0.02
Conn:	Hartford	0.01	N. Dak:	Bismarck	0.01
Del:	Dover	0.01	Ohio:	Cincinnati	—
D. C:	Washington	0.04		Columbus	0.01
Fla:	Jacksonville	0.01		Painesville	0.01
	Miami	0.01	Okla:	Oklahoma City	0.02
Ga:	Atlanta	[a]—		Ponca City	0.02
Guam:	Agana	—	Ore:	Portland	0.02
Hawaii:	Honolulu	0.01	Pa:	Harrisburg	0.01
Idaho:	Boise	0.02	P. R:	San Juan	0.01
Ill:	Springfield	0.01	R. I:	Providence	0.02
Ind:	Indianapolis	0.01	S. C:	Columbia	0.02
Iowa:	Iowa City	0.01	S. Dak:	Pierre	0.02
Kans:	Topeka	0.02	Tenn:	Nashville	0.01
Ky:	Frankfort	0.01	Tex:	Austin	0.01
La:	New Orleans	0.02		El Paso	0.02
Maine:	Augusta	0.02	Utah:	Salt Lake City	0.02
	Presque Isle	0.02	Vt:	Barre	0.02
Md:	Baltimore	0.02	Va:	Richmond	0.01
	Rockville	—	Wash:	Seattle	0.01
Mass:	Lawrence	0.02	W. Va:	Charleston	—
	Winchester	0.02	Wis:	Madison	0.02
Mich:	Lansing	0.02	Wyo:	Cheyenne	0.01

[a] Dash indicates no data received.

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Factors Influencing Gamma Ray Exposure Dose to Nonurban Populations from the Deposition of Nuclear Test Fallout* (*1*)

Harold A. Knapp**

The Problem

The deposition of radioactive fallout on the earth's surface creates a field of penetrating gamma radiation to which all living things in the environment are exposed. At various times and places this field has been directly measurable with instruments, and has been clearly distinguishable from natural background radiation. Except for persons living in the immediate area of the Nevada Test Site, however, there is no simple, sufficiently sensitive radiation detector which may be attached to individuals in the population to make a direct measurement of the external gamma dose they receive from fallout. For this reason it is necessary to calculate the doses and dose rates to which segments of the population in various areas of the country are subjected from various radioactive materials deposited on the ground. The calculations may involve a very complex series of assumptions starting with the quantity of radioactive materials produced at different places and under varying conditions. Or, they may start with a measurement of some aspect of fallout deposition, e.g. the amount of strontium–90 or zirconium–95 deposited per square mile, the total beta activity brought to earth in a rainfall, or the measurement of the gamma dose rate above an open surface.

It is a relatively straightforward matter to compute the dose rate 3 feet above a flat, impenetrable surface uniformly contaminated with a specific nuclide such as cesium–137. But fallout consists of many nuclides, and is rarely deposited uniformly on a flat, impenetrable surface. It irradiates people who spend a significant part of their time in buildings, and at varying distances above the ground.

One purpose of this review is to summarize available information on the reduction of the average external gamma dose rate due to fallout from nuclear weapons tests. These reductions may be attributed to weathering, terrain roughness, and the shielding effect of buildings. A second purpose is to note what can be said as to the distribution of external gamma doses from fallout among the population, composed as it is of persons who spend varying amounts of time out–of–doors and in structures with different shielding characteristics.

It is necessary to distinguish at least four different dose rates and associated doses of interest:

1. The dose rate and resulting accumulated doses which would be experienced in air three feet above an infinite, flat, impenetrable surface if the concentration of fallout on this hypothetical surface were the same per unit area as the fallout actually deposited on the earth's surface. Such a dose rate is usually designated the *infinite plane* dose rate.[1] It is determined solely by the radionuclide composition of the debris and by its density per unit area, since this determines the number and energy of the photons passing through a unit volume of air three feet above the infinite plane.

2. The dose rate and resulting doses which are experienced in air, out–of–doors, three feet above the ground as the result of the deposition of a specified amount of fallout per unit area. This dose rate presumably depends on the outdoor area considered; for example, a city street, a golf course, a forest, or a plowed field. It is

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* Summarized from *Gamma Ray Exposure Dose to Nonurban Populations from the Deposition of Nuclear Test Fallout* in AEC–TID–16457 (July 1, 1962); abridged summary prepared by Dr. Harold A. Knapp.

** Dr. Knapp is a member of the Fallout Studies Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington 25, D.C.

[1] Strictly speaking this is an air ionization rate, measured in roentgens/hour where 1 roentgen is defined as the quantity of X— or gamma radiation such that the associated corpuscular emission per 0.001293 grams of air produces, in air, ions carrying 1 electrostatic unit of electricity of either sign. (The mass of 1 cm^3 of dry atmospheric air is 0.001293 grams at 0° C and 760 mm of mercury pressure.) The unit of absorbed dose is the rad, defined as that amount of ionizing radiation which causes 100 ergs of energy to be absorbed per gram of tissue. An air exposure of 1 roentgen is roughly equivalent to an absorbed dose of 1 rad in human tissue, although some parts of the body are significantly shielded by other parts.

usually less than the corresponding infinite plane dose rate, depending on the shielding afforded by irregularities in the terrain, by objects above ground, and by the leaching of the radioactive materials into the soil by rainfall. However, special terrain situations can *increase* the infinite plane dose rate at particular locations by focusing radiation or concentrating the fallout particles. This out–of–doors dose rate is here designated the *open field* dose rate. In order for the concept to have a precise meaning, it would be necessary to define a "standard open field" and designate the conditions of this field. The gamma dose rate would be appreciably affected, for example, if the field were covered by three feet of wet snow. The center of a football field or any similar, more or less level, open area such as is often found in pastures, golf courses, or around large institutions would probably be sufficiently standard, as well as being a place where measurements might actually be made. Most fallout computations implicitly assume that the concept of a standard or average open field is meaningful and useful, and that the doses and dose rates in air three feet above this field resulting from a specified level of fallout contamination are a suitable measure of the degree by which the environmental gamma background has been changed for wildlife or for a person who remained out–of–doors continuously in a rural area. In terms of the computations, this means that there exists a constant factor "f" by which an infinite plane dose averaged over an area may be multiplied to give a representative environmental dose for that area.

3. The roentgen doses and dose rates to which people are actually exposed when living in an area where the average deposition of radioactive fallout per unit area has been measured or computed. Since people live and work in buildings with widely varying radiation shielding characteristics, and since they spend different amounts of time out–of–doors, it is clear that they would experience different levels of exposure from fallout, even if the fallout were uniformly deposited over the area. It would be logical to ask what average reduction in the open field dose occurs from these causes alone, i.e. without regard to local variations in the fallout deposition per unit area, and to what distribution of doses it gives rise. To obtain the actual distribution of doses it would then be necessary to make detailed studies of the local variations in the distribution of fallout due to natural causes and of the time spent in each location with differing deposition levels. Since available data (*2*) are based on the distribution of measured exposures in a population for a derived average fallout level, and inasmuch as the lack of data on small scale variations in outdoor fallout levels precludes (at least for the present) the usefulness of a concept which allowed for such variations, estimates of the actual distribution of dose to persons are here based on the average concentration of radioactive materials in the area of interest. This concept is simpler to work with, but it could introduce errors of concept or prediction. One can speculate that apart from the shielding obtained by being inside buildings, the same average fallout level in an open prairie and on a wooded mountainside would lead to different exposures of rural populations living in these areas, but it is difficult to try to specify what these differences would be. It is assumed here that it is possible to calculate doses to people in a suitably large area on the basis of an average deposition level over the area, but one should not discount the possibility that this assumption may lead to significant errors if it is assumed that the same factor relating average deposition and average dose to people holds for different areas.

4. The doses from external gamma radiation actually received by different body organs, such as the thyroid, the bone marrow, and the gonads. To a certain extent the internal organs of the body are screened by the body itself, the relative reduction in the dose rate depending upon the energy of the gamma photons and the amount of tissue through which the radiation from various directions must pass. Such reduction factors for various body organs are not further considered here, nor is the fact that different body organs are at different heights above the ground, and that these heights vary for persons of different ages.

Discussion

The principal data upon which the relations between the infinite plane dose and the actual dose to a non-urban population have been estimated were collected by U.S. Public Health Service. As reported by Reed (*2*):

> p. 5 "The U.S. Public Health Service Off-Site Rad-Safety Organization furnished film badges to a large number of people in and around Nevada during Operation Plumbbob (1957). These badges were used to measure population exposure to test fallout. A large number of badges were placed at fixed points in and around inhabited places to measure area fallout exposure. The USPHS collected and developed these badges and listed the measured radiation doses. These numbers were added to dose from earlier operations to show maximum total lifetime doses to various communities. *The listing showed that badges on people averaged only two-thirds as much radiation as was recorded by badges mounted at fixed points out-of-doors.*"

> p. 6 "Individual comparisons between badge and map doses show a broad range of differences. Under what seem to be similar conditions, different persons received different measured doses. This scatter in results of comparisons is important in finding or forecasting the most radiation that human beings might get from living in a fallout pattern."

> p. 10 ". . . it was found that most badge collections for specific locations had a distribution of non-zero readings which closely followed the logarithmic normal distribution. This distribution is commonly valid when measuring errors are nearly as large as measured magnitudes, and negative values are not possible. *What this means is that the probability of observing a value greater than X times the mean value is the same as the probability of observing a value smaller than 1/X times the mean value.*"[2]

Reed's report does not give a detailed account of the conditions under which the fixed point and personal film badges were exposed, nor does it state exactly how the fixed badges were located with respect to structures which could provide possible shielding. Further, it is not certain that the badges represented a suitable average of the open field dose in the areas where badges on people were also exposed, although it is assumed here that this is the case. Thus it is *tentatively* concluded that the average shielding effect of buildings on a population reduces the average exposure to $\frac{2}{3}$ of the open field exposure. If terrain roughness reduces the open field dose to $\frac{3}{4}$ of the infinite plane dose, Reed's result would lead to the conclusion that the population was exposed on the average to $\frac{3}{4} \times \frac{2}{3} = \frac{1}{2}$ of the infinite plane dose for the first year, providing weathering is not an important factor during this time. This conclusion assumes that for world-wide stratospheric fallout the relations between the infinite plane dose, the open field dose, and the dose received by the U.S. population generally are the same as those which describe these doses in the communities around the Nevada Test Site from the tropospheric fallout from Nevada tests. This is a big assumption which needs detailed investigation, but presumably it is better than no information at all.

Three conclusions from Reed's report were accepted without change and used to draw specific conclusions concerning the distribution of dose amongst the population.

They are:

(1) that the average value (the arithmetic mean) of the badges on people was two-thirds the average value recorded by the badges mounted at fixed points out-of-doors, and that these badges mounted out-of-doors measured the open field dose,

(2) that the distribution of doses to people from Nevada fallout is accurately described by the film badge samples, for the time during which the badges were exposed, and that this distribution is, within the limits considered later, lognormal, and

(3) that Reed's computation of the parameter describing the spread in values of the doses to the population (e.g., the fraction which is x times and $1/x$ times the *median* value, called the *mean* value by Reed) is correct.

These conclusions and their implications are understandable only in terms of the definition and properties of the lognormal distribution.

A statistical variable x which takes on only positive values is said to be lognormally distributed if the natural logarithm of x (here

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[2] Reed's use of the term *mean* value here is not strictly correct. It is the *median* value, of the lognormal distribution which has this property.

denoted as $\ln x$) is normally distributed. Letting $y = \ln x$, this means that there exists a mean m and a standard deviation σ such that the distribution function for y, $F(y)$, is given by

$$F(y) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}[(y-m)^2/\sigma^2]}$$

From the properties of distribution functions in general this means that the probability that y will lie between y_1 and y_2 is

$$\int_{y_1}^{y_2} F(y)\, dy.$$

The distribution function for x, $f(x)$ is then determined to be

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{1}{2}[(\ln x-m)^2/\sigma^2]}$$

and the probability that x will lie between x_1 and x_2 is

$$\int_{x_1}^{x_2} f(x)\, dx.$$

Letting D be the infinite plane dose from time of arrival to 1 year, the values of σ and m obtained from Reed's report are then given by the relations

$$e^m = .326D,$$

and

$$e^\sigma = 2.55,$$

where e = 2.7183 is the base of natural logarithm.

Conclusions

1.There is little definitive evidence to indicate the extent to which the theoretical air dose three feet above a smooth, impenetrable, infinite plane contaminated with the measured surface concentration of fallout should be reduced to obtain the average gamma ray exposure of the population. It has often been assumed that the average dose to people is from ⅕ to $^1/_{10}$ the infinite plane dose. It is tentatively concluded that for the first year following fallout, the average dose to the non-urban population of the U.S. lies between $^3/_{10}$ and $^5/_{10}$ of the infinite plane dose. Film badge readings on people living in the vicinity of the Nevada Test Site are reported (*2*) as averaging two-thirds the average reading on badges placed at fixed locations out-of-doors. This result, together with the conclusion that due primarily to terrain roughness the open field dose for the first year following deposition would average ¾ of the infinite plane dose, lead to the tentative conclusion that for a year following deposition, the average dose to a population group in the U.S. can be as much as ⅔ x ¾ = ½ the infinite plane dose for time periods extending up to 1 year following detonation. No attempt is made to estimate the corresponding reduction for persons who live in cities. That could be much less.

2. For a radionuclide such as cesium-137 (half-life 30 years) which delivers its potential 30- and 70-year exposures slowly over a lifetime, the total dose depends critically on long-range weathering effects. If the actual dose rate to people from cesium-137 released to the environment were to be reduced by a factor of 2 every 10 years instead of every 30 years as dictated by radiological decay, the lifetime (70-year) dose from material which originally gave a dose rate of 1 mrad/year would be cut from 34.6 mrad to 14.2 mrad. Were the dose rate to decrease by a factor of 2 every 5 years, the lifetime dose would be reduced to 7.2 mrad. Thus it is possible that weathering considerations may have a large influence on the potential dose received from cesium-137, even though it appears that they have little effect on the potential dose from a short- or intermediate-lived nuclide such as zirconium-95 (half-life 63 days).

3. The conclusions drawn from analysis of film badges in the Nevada radiation safety monitoring program suggest that the distribution of dose to a population in a more or less uniformly contaminated area is, within uncertain limits, approximated by a lognormal distribution function in such a way that ⅙ of the population receives at least 1.7 times the average dose. If this lognormal distribution function is extrapolated, it leads to the conclusion that 2.5 percent of the population receives at least 4 times the average exposure, but the validity of such an extrapolation is unknown.

4. The air ionization rate r at 3 feet above a flat, impenetrable, infinite plane uniformly con-

taminated with M megacuries of a radioactive nuclide per square mile (or C curies per square meter) may be approximated by $r = 7.7\ M\gamma$ (or $r = 3.0\ C\gamma$) roentgens/hour, where γ is the average gamma energy released per disintegration, expressed in Mev. This formula is approximately correct when the energy of the individual gamma photons (as opposed to the total gamma photon energy emitted per disintegration) lies in the range from 0.1 to 1.5 Mev. It is generally applicable to individual fission products, or to collections of fission products. It gives ionization rates 10 percent higher than those indicated in the "Effects of Nuclear Weapons" (*3*). For some applications it is more convenient to redefine M as the total number of gamma megacuries per square mile and γ as the average energy of the gamma photons, but one must take care to be consistent as to which scheme is being used.[3]

5. Following a 1954 estimate by J. Hill of the RAND Corporation (*4*), the dose rate three feet above an open field is estimated to be reduced by terrain roughness to approximately 87 percent of what it would be above an infinite, smooth plane. In steep, rough terrain, Hill indicates a reduction to about 58 percent of the infinite plane value, and in residential areas to approximately 70 percent to 80 percent of the infinite plane value.

6. Reduction of the external gamma dose rate by weathering—that is the leaching of radioactive particles into the soil by rainfall—is highly uncertain, but from the evidence available it is concluded that weathering cannot be expected to make an appreciable difference for about a year, and that for several years thereafter the open field dose rate would not be reduced by more than 30 percent from this effect.

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(*3*) U.S. Department of Defense: *Effects of Nuclear Weapons*, U.S. Atomic Energy Commission, Washington, D.C. (April 1962), p. 492.

(*4*) J. Hill: Effects of Environment in Reducing Dose Rates Produced by Radioactive Fallout from Nuclear Explosions, *RAND RM-1285*, (September 28, 1954).

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[3] It is often difficult to find agreement between authors as to the value of γ appropriate for specific gamma emitting radionuclides. The computation of γ may in fact be quite difficult, and the nuclear data upon which the computations are based changes frequently.

Iodine–131 in Milk and Vegetables Associated With July 1962 Fallout in Utah*

The July 8, 1962 Radiation Surveillance Network (RSN) report of a relatively high field estimate of gross beta activity on an air filter sample collected in Salt Lake City, Utah, set in motion intensified milk and other environmental samplings in that area. The Salt Lake City cooperative pasteurized milk sampling effort of the Utah State and Salt Lake City Health Departments and the Public Health Service was stepped up to a daily sampling schedule (*1*). Additionally, the Food and Drug Administration began collecting vegetable samples from the growing areas surrounding Salt Lake City. Available data from these sampling activities, the U.S. Weather Bureau and the U.S. Atomic Energy Commission reports on nuclear detonations at the Nevada Test Site, have been assembled and are presented in this report.

Certain public health protective measures were initiated by the Salt Lake City and Utah State Health Departments in the Salt Lake City milk collection area on August 1, 1962. The measures included the diversion of fluid milk to manufacturing plants and the use of stored feed for the cattle in place of pasture grass. The effect of these measures in reducing radioactivity concentration in milk is not considered in this report since the data presented concern primarily the period before August 1.

The purpose of this article is to present the time sequences of various events which might have been associated with the July increase of iodine–131 in Salt Lake City milk and leafy vegetables, as a step in further relating some of the factors that may lead to the appearance of iodine–131 in milk and other foods.

Whenever radiological contamination occurs near a test site there is great interest in trying to relate the contamination to a specific nuclear detonation. When multiple detonations occur in short intervals, this invariably leads to differences of opinion as to the origin of the specific contaminated radionuclide. The data presented here is an effort to consider this situation on the basis of data normally available to the public health agencies. It is hoped that this information, with that of other scientific contributors and reviewers, may help us to better understand the events that took place in the interest of both public health agencies and those responsible for the nuclear testing program which is essential for national defense.

IODINE–131 IN PASTEURIZED MILK

Division of Radiological Health,
Public Health Service

The Salt Lake City station of the Public Health Service Pasteurized Milk Network began daily sampling of pasteurized milk on July 10, 1962, as a result of an alert from the Radia-

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* Compiled and developed by Mr. Robert G. Bostrom, *RHD* Staff.

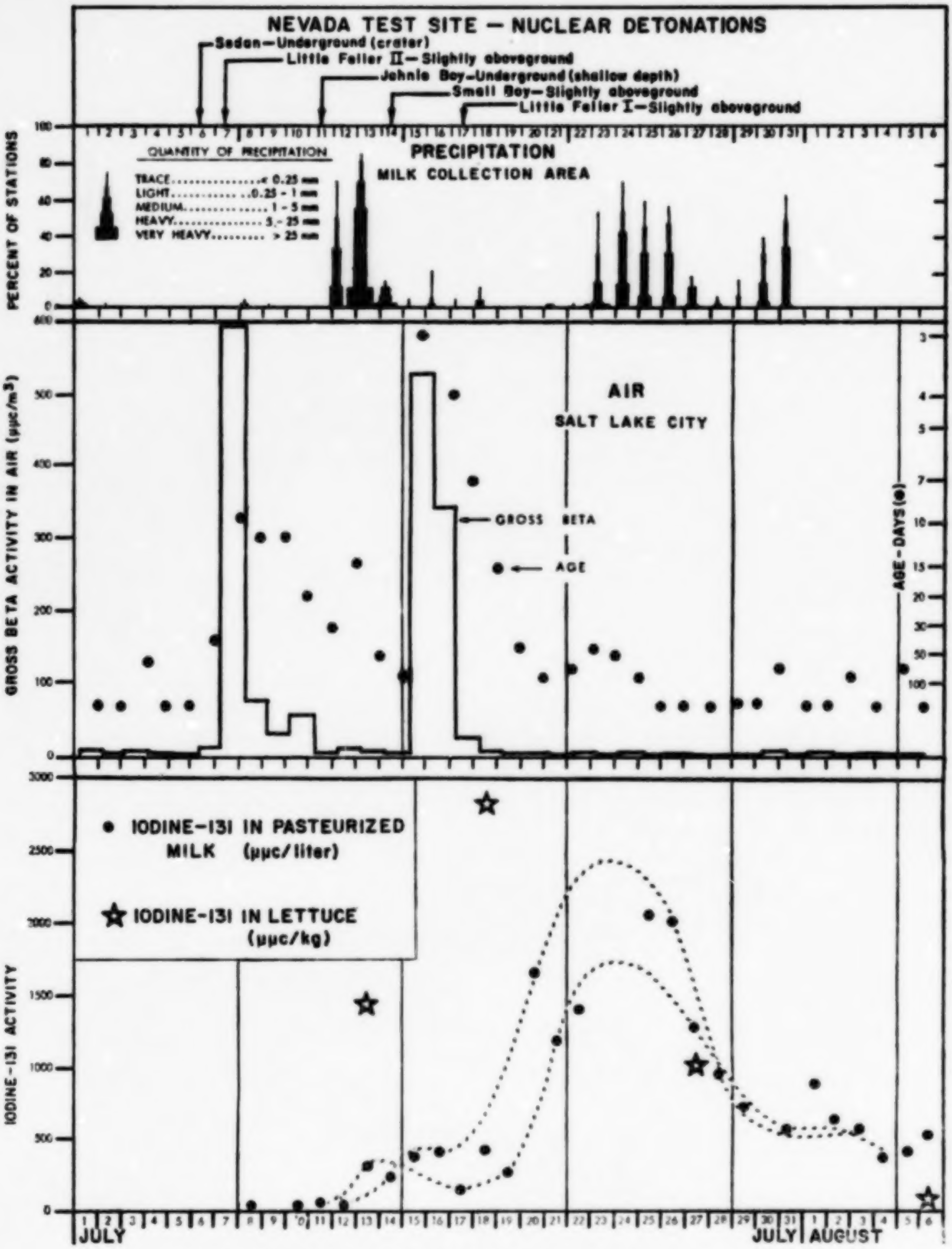
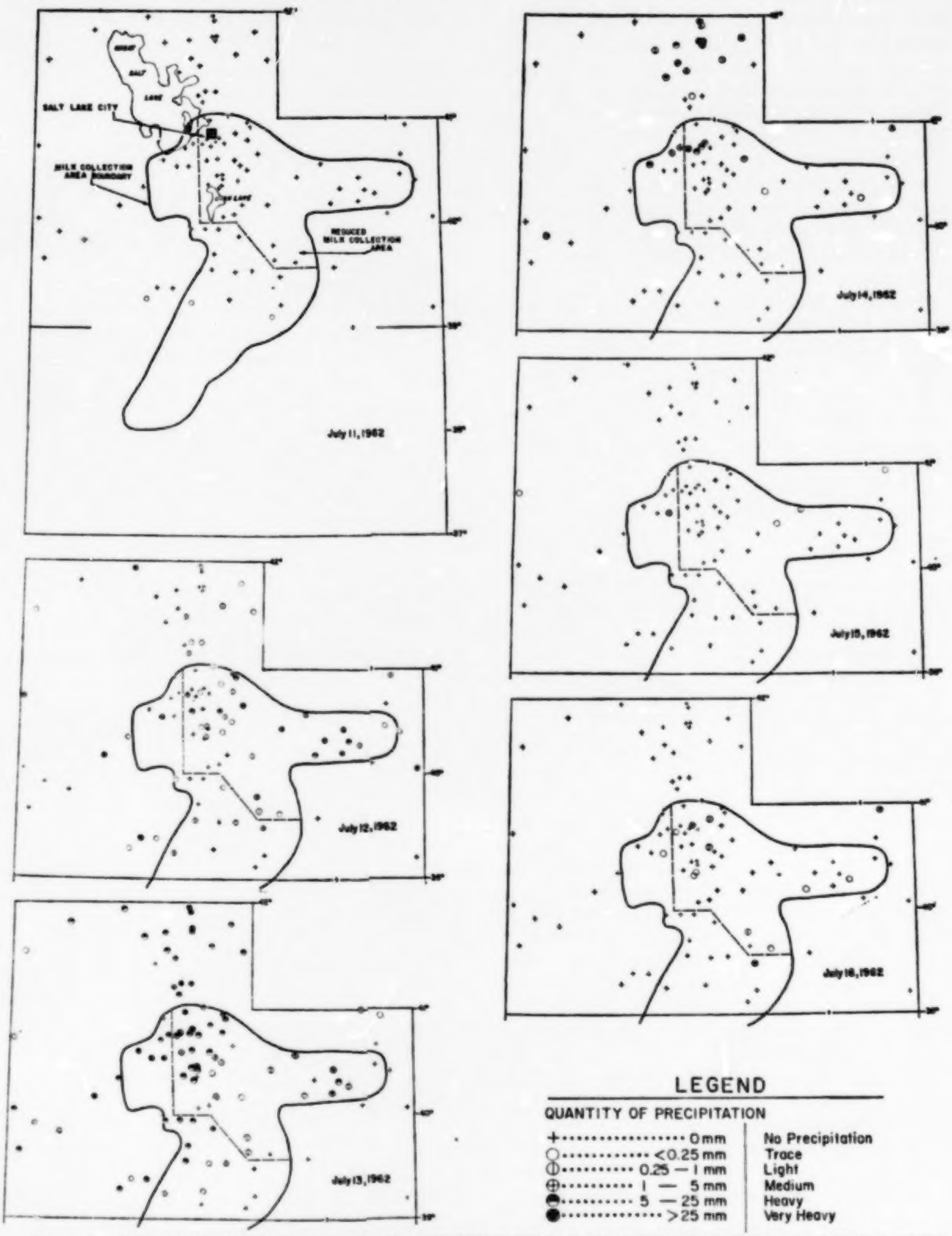


Figure 1.—CHRONOLOGICAL COMPARISON OF DATA, UTAH, JULY 1962



GREAT SALT LAKE
SALT LAKE CITY
MILK COLLECTION AREA BOUNDARY
UTAH LAKE
REDUCED MILK COLLECTION AREA
July 11, 1962
July 12, 1962
July 13, 1962
July 14, 1962
July 15, 1962
July 16, 1962
LEGEND
QUANTITY OF PRECIPITATION
0 mm No Precipitation
<0.25 mm Trace
0.25 — 1 mm Light
1 — 5 mm Medium
5 — 25 mm Heavy
>25 mm Very Heavy

Figure 2.—PRECIPITATION RECORDED IN AND NEAR THE SALT LAKE CITY MILK COLLECTION AREA

tion Surveillance Network field estimate of gross beta in air on July 8. Daily iodine-131 concentrations in Salt Lake City pasteurized milk for July and a portion of August 1962 are tabulated in table 1 and presented graphically in figure 1.

The PHS milk sample is a composite of samples of pasteurized milk from nearly all of the dairies (pasteurizing plants) in Salt Lake City. Each dairy receives its raw milk in large tank trucks from farms on regular alternate day schedules.

The milk collection area of Salt Lake City extends approximately 150 miles to the east and 220 miles to the south of the city as shown in figure 2. The area includes both irrigated valleys and intervening mountain ranges. It is believed that at least 90 percent of the area's milk production is represented by a portion of the milk collection area east of Salt Lake City and Lake Utah. This section of the milk collection area, delineated by a dashed-line boundary in figure 2, is used as the basis for the precipitation analyses shown in figure 1 and table 3.

The milk flow pattern in the Salt Lake milk collection area is complex and does not lend itself readily to a simple outline nor a scientifically representative sampling procedure. However, the pattern can be outlined in a general way and data from the samples collected are useful for comparative purposes.

The tank trucks pick up from roughly half of the farms on odd days of the month and from the remainder on even days. Each collection is composed of a mixture of milk from 4 milkings, including the morning milking of the day of collection and the evening milking of the day the previous collection was made. The time interval between morning milking (usually about 6:00 a.m.) on the day of collection and the time of delivery of the milk to the dairy varies from about 6 to 18 hours, depending on the area of collection for the individual truck. Flow-through time in the dairy for pasteurizing, bottling, and handling takes as little as two hours. The PHS samples are usually collected in late afternoon so that a large portion of the day's milk collection is represented. Samples collected on Sundays and Wednesdays, however, represent the previous day's collection since the pasteurizing plants are not in operation on those days.

RADIOACTIVITY IN LETTUCE

Division of Pharmacology,
Food and Drug Administration

Several types of leafy vegetables were sampled by the Food and Drug Administration in the vicinity of Salt Lake City during July and August in response to the alert signalled by the peaks of gross beta in air detected in that city on July 8 and 16.

Lettuce, including leaf lettuce and endive, but not head lettuce, was selected for sampling purposes. Lettuce samples from six farms in the vicinity of Salt Lake City were collected on each of the four sampling dates, July 13, 18, 27, and August 6. The samples (unwashed) were analyzed for iodine-131, strontium-90, and total beta activity. Iodine-131 was determined by measurement of the 0.36 Mev peak in the gamma spectrum using a 3″ X 3″ thallium activated sodium iodide crystal and a 400-channel analyzer. Average concentrations for each set of six samples are presented in table 2. The profile of iodine-131 concentration in lettuce (including endive) is plotted in figure 1.

TABLE 1.—IODINE-131 IN PASTEURIZED MILK AT SALT LAKE CITY, UTAH

Date	Iodine-131 (μμc/liter)	Date	Iodine-131 (μμc/liter)
July 1, 1962	[a] —	July 20, 1962	1,660
2	—	21	1,190
3	<10	22	1,390
4	—	23	—
5	—	24	—
6	<10	25	2,050
7	—	26	2,000
8	<10	27	1,290
9	—	28	960
10	20	29	730
11	60	30	—
12	30	31	570
13	300	August 1, 1962	890
14	250	2	640
15	390	3	590
16	410	4	370
17	160	5	410
18	450	6	520
19	280		

[a] Dash denotes no samples collected.

TABLE 2.—RADIOACTIVITY IN LETTUCE SAMPLES COLLECTED IN THE SALT LAKE CITY AREA

[concentrations in μμc/kg (fresh weight)]

Date [a] of harvest 1962	Total beta	Strontium-90	Iodine-131
July 13	25,650	26	1,437
18	44,000	63	2,812
27	18,450	53	1,014
August 6	8,100	33	3

[a] Six samples were collected on each date and the results averaged.

AIR AND PRECIPITATION FACTORS

Division of Radiological Health,
Public Health Service

Continuous daily filter samples of airborne particulates are collected by the Radiation Surveillance Network in Salt Lake City and in 70 other stations throughout the United States. A field estimate of the gross beta activity on the filter is made before sending the filter to the central laboratory for more accurate determination of beta activity and estimation of age of fission products. Although the field estimates served as the alert signal, the final laboratory measurements of gross beta activity in Salt Lake City surface air are plotted in figure 1. The estimated age of fission products, also plotted in figure 1, is determined by the Way-Wigner method discussed on page 462. This method does not give accurate age estimates for underground detonations, presumably because of fractionation of fission products and neutron activation of soil particles. However, the estimated ages presented in figure 1 may at least indicate general freshness of fission product activity. Examination of this figure shows that peaks of young fission product activity occurred on July 7–8 and July 15–17.

To give a broader geographical picture of atmospheric radioactivity, maps of the United States with beta concentration contours and age of fission product contours for a limited number of days are presented in figure 5. Also included in this figure are maps showing precipitation depth, other meteorological information, and precipitation fission product activity.

Precipitation samples are also collected by RSN in Salt Lake City and analyzed for gross beta and age of fission products (see table 3). However, during July, only two days (July 13 and 14) yielded enough rain to sample. Further, the activity in these precipitation samples cannot be considered representative of the entire milk collection area.

Precipitation depth measurements made by 100 Weather Bureau cooperative stations in northern Utah (*3*) are given day by day on the maps in figure 2. Table 3 summarizes the data in terms of estimated average intensity of pre-

TABLE 3.—PRECIPITATION IN THE SALT LAKE CITY MILK COLLECTION AREA, JULY 1962

Date [a] July, 1962	Precipitation in abbreviated milk collection area (43 Weather Bureau cooperative stations)		Salt Lake City precipitation (RSN)		
			Depth (mm)	Fission product activity	
	Percent of stations reporting some precipitation	Average precipitation reported (mm)		Deposition (mμc/m²)	Age (days)
1	7	3.0	—	—	—
2	2	trace	—	—	—
3	[b]—	—	—	—	—
4	—	—	—	—	—
5	—	—	—	—	—
6	—	—	—	—	—
7	—	—	—	—	—
8	5	1.1	—	—	—
9	2	trace	—	—	—
10	—	—	—	—	—
11	—	—	—	—	—
12	70	2.8	—	—	—
13	84	10.0	12.3	97	28
14	16	9.5	8.7	41	46
15	5	0.2	—	—	—
16	21	0.2	—	—	—
17	5	trace	—	—	—
18	12	1.2	—	—	—
19	—	—	—	—	—
20	—	—	—	—	—
21	2	3.5	—	—	—
22	2	trace	—	—	—
23	54	2.0	—	—	—
24	68	2.2	—	—	—
25	60	2.5	—	—	—
26	56	2.2	—	—	—
27	19	3.5	—	—	—
28	5	1.5	—	—	—
29	16	0.2	—	—	—
30	40	1.5	—	—	—
31	63	1.2	—	—	—

[a] The data is that of the end of the sampling period: 6:00 p.m. for Weather Bureau cooperative stations and 8:00 a.m. for the RSN station.
[b] Dash denotes no precipitation reported.

cipitation in the milk collection area and the estimated percent of milk collection area having rain.[1] Although no radioactivity measurements have been made of these precipitation samples, the activity recorded in the Salt Lake City precipitation, together with the concurrent presence of precipitation in other parts of the milk collection area suggests the possibility of deposition of fresh fission products.

Little or no precipitation occurred during the first part of the month on the Salt Lake City milk collection area until the widespread rains of July 12 and 13. For the rest of the month scattered trace and light rains occurred from time to time throughout the area.

METEOROLOGICAL TRAJECTORIES OF DEBRIS FROM NUCLEAR DETONATIONS

Weather Bureau,
U.S. Department of Commerce

The Atomic Energy Commission announced that five nuclear detonations conducted at the Nevada Test Site during July 1962 released radioactivity into the atmosphere (see table 4).

Meteorological trajectories (see figure 3) of the air, which carried the debris from the various detonations listed, have been computed by the Weather Bureau Research Station, Las Vegas, Nevada. These trajectories depict the path of air mass for constant heights above mean sea level (MSL), which may contain gaseous or small-particle debris which has a negligible fall rate. The meteorological trajectories are based on the wind analyses for the various levels and take into account the temporal and spatial changes in the wind. Meteorological trajectories are, of course, subject to error, particularly over regions of sparse data or in areas of rapidly changing or complex flow patterns.

ANALYSIS OF DATA

Milk

Iodine–131 kinetics in the lactating cow have been studied by various investigators. Garner has detected iodine–131 in milk in as little as 30 minutes after the cow's ingestion of 1 mc of iodine–131 (4). Analyses on milk from three herds of cows (three different States) that were removed from pasturage and put on stored feed showed initial declines of the iodine–131 concentration corresponding to effective half–lives of 16 hours to 2 days.[2] The milk from one of the herds was analyzed daily and showed an effective half–life for iodine–131 of 16 hours for the first 3 or 4 days followed by an effective half–life of between 7 and 8 days.[2] For this analysis a one–day effective half–life for iodine–131 in udder milk and a 7–day half–life in pasturage are assumed. Using these values it is estimated that a cow's continous ingestion of pasturage initially contaminated with iodine–131 would result in a peak of activity in milk in 3.3 days.[3] Using these assumed

TABLE 4.—NUCLEAR TESTS AT NEVADA TEST SITE WHICH RELEASED RADIOACTIVITY TO THE ATMOSPHERE IN JULY 1962

Date	*Time (PDT)*	*Name*	*Type*	*Yield*	*Approximate Cloud Height Above Ground*
6 July	1000	Sedan*	635 feet underground	about 100 Kt	12,000 feet
7 July	1200	Little Feller II	slightly above ground	low	8,000 feet
11 July	0945	Johnie Boy	shallow underground	low	11,000 feet
14 July	1130	Small Boy	a few feet above ground	low	15,000 feet
17 July	1050	Little Feller I	slightly above ground	low	10,000 feet

*AEC news release. "The device used was a relatively 'clean' thermonuclear device in which fission contributed less than 30 percent of the total yield." . . . "As expected, most of the radioactivity produced by the explosion was trapped underground. A precise determination of the percentage of escaping radioactivity cannot be obtained from the available preliminary data, but these data do show that there was no major deviation from the prediction that about 95 percent of the radioactivity would be trapped in the ground."

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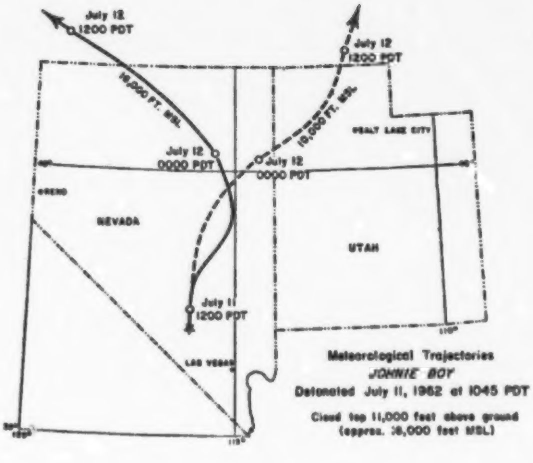
[1] The milk collection area used here is the portion of the area north and east of the dashed–line in figure 2. This area is believed to represent more than 90 percent of the regular Salt Lake City milk supply.

[2] Personal communication from Dr. C. P. Straub, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

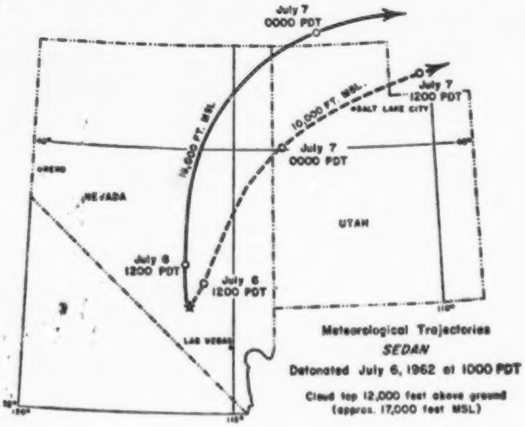
[3] $$t(C)_{max} = \frac{3.323\, T_A\, T_B}{T_A - T_B} \log \frac{T_A}{T_B}$$

Overman, Ralph T., and H. M. Clark: *Radioisotope Techniques*, McGraw-Hill, (1960), p. 303.

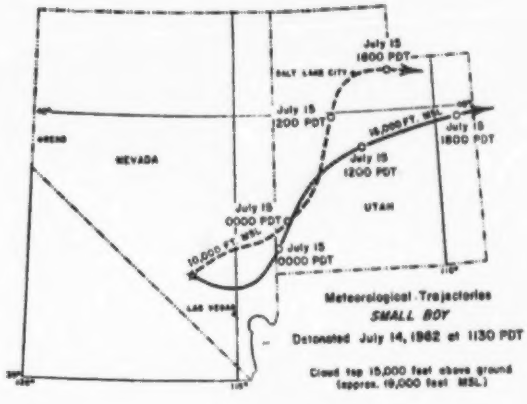
(By analogy, C is the concentration of iodine–131 in udder milk and therefore, $t\,(C)_{max}$ is the time at which the concentration in udder milk is a maximum, T_A is effective half-life of iodine–131 in pasturage and T_B is effective half-life of iodine–131 in udder milk.)


July 12
1200 PDT
10,000 FT. MSL
July 12
1200 PDT
10,000 FT. MSL
SALT LAKE CITY
July 12
0000 PDT
July 12
0000 PDT
40°
RENO
NEVADA
UTAH
July 11
1200 PDT
110°
LAS VEGAS
36°
120°
115°

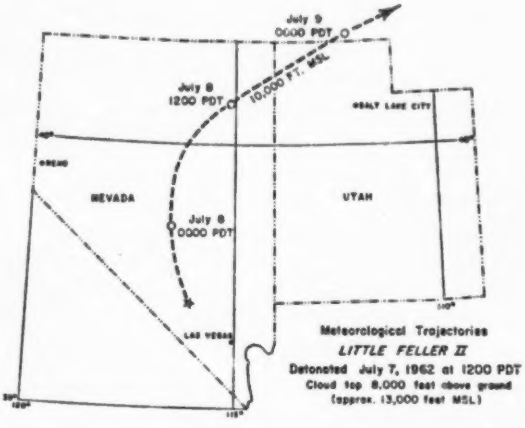
Meteorological Trajectories
JOHNIE BOY
Detonated July 11, 1962 at 1045 PDT
Cloud top 11,000 feet above ground
(approx. 16,000 feet MSL)


July 7
0000 PDT
July 7
1200 PDT
10,000 FT. MSL
SALT LAKE CITY
10,000 FT. MSL
July 7
0000 PDT
40°
RENO
NEVADA
UTAH
July 6
1200 PDT
July 6
1200 PDT
110°
LAS VEGAS
36°
120°
115°

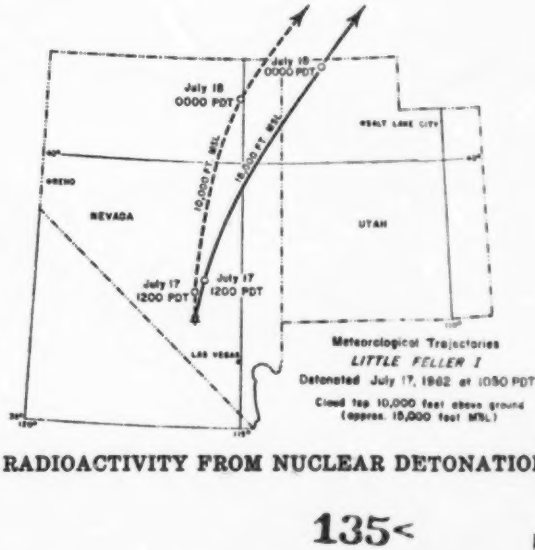
Meteorological Trajectories
SEDAN
Detonated July 6, 1962 at 1000 PDT
Cloud top 12,000 feet above ground
(approx. 17,000 feet MSL)


July 15
1800 PDT
SALT LAKE CITY
July 15
1200 PDT
10,000 FT. MSL
July 15
1800 PDT
40°
RENO
NEVADA
July 15
1200 PDT
UTAH
July 15
0000 PDT
10,000 FT. MSL
July 15
0000 PDT
110°
LAS VEGAS
36°
120°
115°

Meteorological Trajectories
SMALL BOY
Detonated July 14, 1962 at 1130 PDT
Cloud top 15,000 feet above ground
(approx. 19,000 feet MSL)


July 9
0000 PDT
July 8
1200 PDT
10,000 FT. MSL
SALT LAKE CITY
40°
RENO
NEVADA
UTAH
July 8
0000 PDT
110°
LAS VEGAS
36°
120°
115°

Meteorological Trajectories
LITTLE FELLER II
Detonated July 7, 1962 at 1200 PDT
Cloud top 8,000 feet above ground
(approx. 13,000 feet MSL)


July 18
0000 PDT
July 18
0000 PDT
SALT LAKE CITY
10,000 FT. MSL
10,000 FT. MSL
40°
RENO
NEVADA
UTAH
July 17
1200 PDT
July 17
1200 PDT
110°
LAS VEGAS
36°
120°
115°

Meteorological Trajectories
LITTLE FELLER I
Detonated July 17, 1962 at 1030 PDT
Cloud top 10,000 feet above ground
(approx. 15,000 feet MSL)

Figure 3.—METEOROLOGICAL TRAJECTORIES OF RADIOACTIVITY FROM NUCLEAR DETONATIONS

values, the hypothetical curves in figure 4 were drawn to depict possible time relationships between initial fallout and appearance and peaks of iodine–131 in pasteurized milk. The shapes of these curves may possibly be modified by such variables as (1) reinforcement of activity in pasturage by continual deposition; washoff of activity by rains of low activity; and (3) growth of new grass after deposition. The "case A" curves represent a hypothetical situation in which most of the iodine–131 on pasturage was washed off very shortly after it was initially deposited. In "case B," however, the deposited iodine–131 remained on the pasturage for several days after deposition, decreasing in concentration with an effective half–life nearly equal to the physical half–life of 8 days. Here a 7–day half–life was assumed allowing for some effect from plant growth.

Depending on the tank truck milk collection schedules, the time sequence for pasteurizing, and the PHS sample collection, the time required for milk from a given milking to reach a PHS pasteurized milk sample may vary from 10 hours to 3 days. This time delay for storage, transportation, and processing is also depicted in figure 4.

By interrelating the curve for iodine–131 in udder milk with the time lag for storing, transporting, and processing (figure 4), it may be expected that some iodine–131 may be detected in a PHS sample collected as little as 12 hours after the radioactivity was deposited on the pasturage. Furthermore, the maximum concentration of iodine–131 in a series of PHS pasteurized milk samples, assuming the effective half–life of one day for iodine–131 in udder milk, would probably occur 3 to 6 days after the deposition of activity under the conditions depicted in figure 4.

Iodine–131 concentrations in pasteurized milk during July can be roughly separated into four general phases: (1) *initial appearance*, July 8–12, with concentrations ranging from 20 to 60 μμc/liter; (2) *plateau stage*, July 13–19, 160–450 μμc/liter; (3) *peak stage*, July 20–26, 1190–2050 μμc/liter; and (4) *decline stage*, July 27–31, with a downslope approximating a 3–day half–life.

The question may be raised whether the alternate day milk collection schedules may affect the daily pasteurized milk sample iodine–131 activities because of day-to-day differences in the geographical source of milk. The two broken line curves in figure 1 reflect these activities. One curve represents iodine–131 in milk sampled on even dates in July and the other on odd dates (excluding Sundays and Wednesdays because of dairy plant shutdown). The successive variations between the two curves suggest that the alternate day milk collection schedules may influence the iodine–131 values in the composite pasteurized milk sample.

Lettuce

A comparison of the iodine–131 concentrations in the four sets of lettuce samples leads to the question of what may have occurred during the time periods between samplings to yield the observed concentrations.

If lettuce were sampled daily, the resulting iodine–131 profile would probably have characteristics similar to the hypothetical iodine–131 profile for pasturage in figure 4. Sharp decreases could occur as a result of washoff by rains of low radioactivity. During the periods between the depositions or washoffs, the profile would be expected to show a gradual decrease with a half–life of about 8 days (physical half–life of iodine–131) or slightly less because of the diluting effect of plant growth.

Using the profile characteristics discussed above, it would appear that at some time between the July 13 and July 18 lettuce sampling dates deposition occurred, resulting in about a three–fold increase in iodine–131. There is no evidence of any deposition of activity during the July 18–27 interval in view of the fact that the observed decrease approximates a 6–day half–life. However, a combination of deposition and washoff during the interval cannot be ruled out. The much greater relative decrease observed between July 27 and August 6 may be accounted for by plant growth, washoff, and/or experimental uncertainties besides the normal decay of iodine–131.

It is interesting to note that the strontium–90 values for lettuce also indicate nearly a three–fold increase by deposition in the first time interval, July 13–18, and decreases in the remaining two intervals (see table 2). This observation, together with the low strontium–90

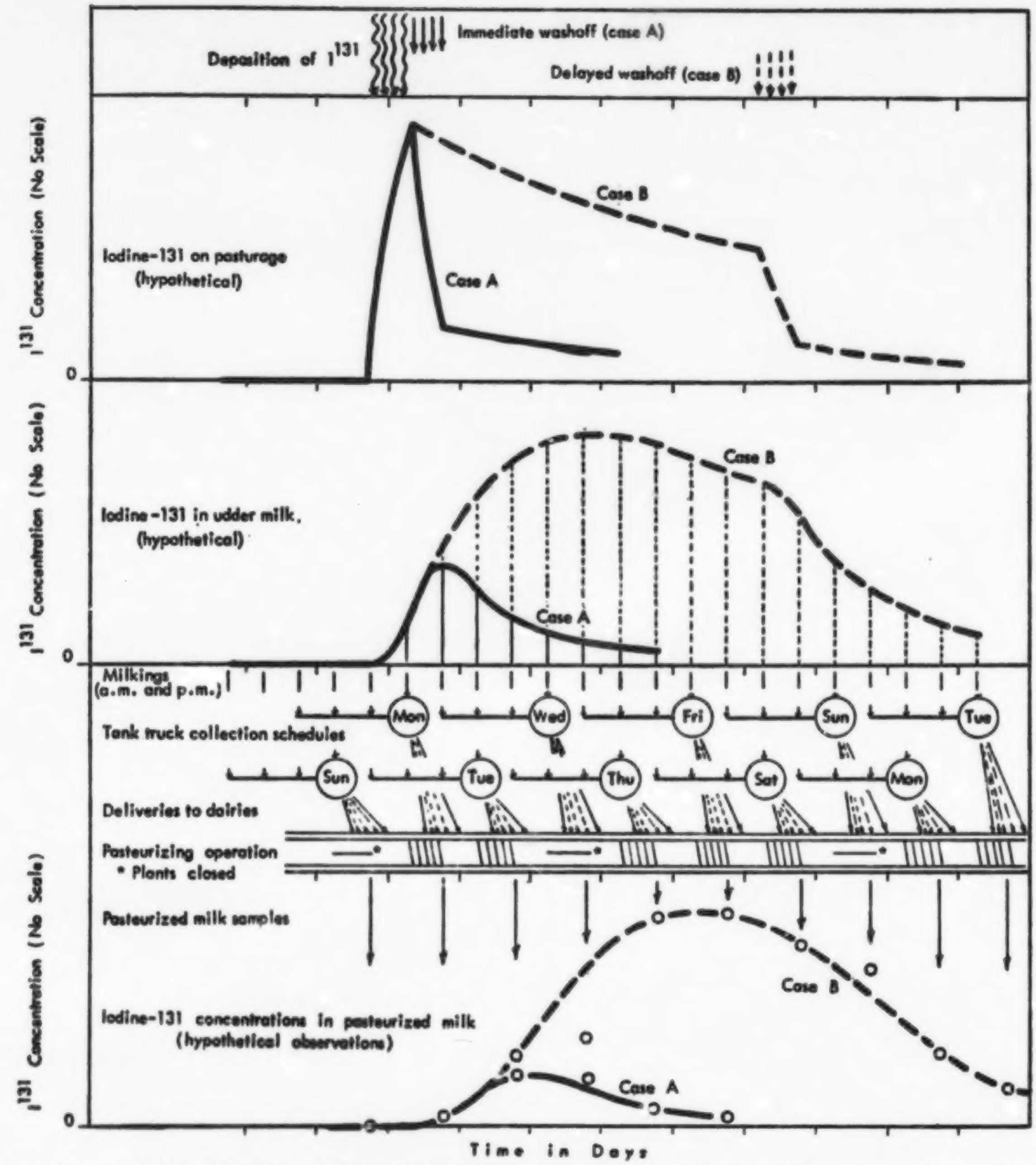

Deposition of I^{131}
Immediate washoff (case A)
Delayed washoff (case B)
I^{131} Concentration (No Scale)
Iodine-131 on pasturage (hypothetical)
Case B
Case A
0
I^{131} Concentration (No Scale)
Iodine-131 in udder milk, (hypothetical)
Case B
Case A
0
Milkings (a.m. and p.m.)
Tank truck collection schedules
Mon
Wed
Fri
Sun
Tue
Sun
Tue
Thu
Sat
Mon
Deliveries to dairies
Pasteurizing operation
* Plants closed
Pasteurized milk samples
I^{131} Concentration (No Scale)
Iodine-131 concentrations in pasteurized milk (hypothetical observations)
Case B
Case A
0
Time in Days

Figure 4.—HYPOTHESIZED TIME SEQUENCE RELATIONSHIPS FOR THE SALT LAKE CITY MILK COLLECTION AREA. This figure does not represent any given dates but is intended as an aid in visualizing approximate time relationships between initial fallout and appearance of iodine-131 in pasteurized milk using current Salt Lake City milk collection and pasteurizing schedules, and an assumed one-day effective half-life for iodine-131 in udder milk.

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to total beta ratios[5] and the relatively short growing period for lettuce indicates that most of the strontium-90 measured in the lettuce samples probably was deposited during July.

Comparison Between Times of Appearance of Iodine-131 in Milk and Lettuce

Some comparability between the relative concentrations of iodine-131 in milk and leaf lettuce could be expected on the assumption that leaf lettuce acts similar to pasturage as a fallout (wet and dry) collector. However, it must be borne in mind that there is an inherent lag ranging from 12 hours to 2 days or more between fallout deposition and initial appearance of iodine-131 in pasteurized milk, but with the lettuce samples there was no time lag. Furthermore, the milk was collected from a large area, but the lettuce was collected in the immediate vicinity of Salt Lake City.

Figure 1 suggests that the lettuce values fit as expected with the milk profile, leading the latter by at least two days.

Comparison of Air and Precipitation Data with Iodine-131 in Milk

Comparisons are made in this section between air and precipitation data and the levels of iodine-131 in Salt Lake City milk during the first phases described above.

The first phase, July 8-12, representing the initial appearance of iodine-131 in milk (see figure 1 and table 1), appears to be associated with the gross beta peak evidenced by the July 8 RSN air sample in Salt Lake City. It is not certain, however, how much of the milk collection area was covered by the air mass having the beta activity. Some small dry fallout onto pasture grass is implied by the iodine-131 values in milk, since there was an apparent absence of precipitation in the milk collection area during the period July 7-10 (see figure 1). Localized rains in the area, however, cannot be ruled out. Another possible explanation for the presence of iodine-131 in milk is the inhalation of airborne iodine-131 by cows.

The second or plateau phase shown on the milk profiles, July 13-19, is more complex. The early part of the plateau could be due to the widespread rains over most of the milk collection area on July 12 and 13. Suggesting this is the combination of the fresh fission product activity detected in the RSN precipitation samples (see table 3) from Salt Lake City and the time sequence involved. Presumptively, these young fission products may have been present in the rain in other parts of the milk collection area as well. The later part of the plateau may also have been influenced by other more scattered rains on July 14, 15, and 16 or by dry fallout associated with the second peak of gross beta activity in air detected in Salt Lake City on July 16 and 17.

The third phase of the milk profile, July 20-26, showing a peak of iodine-131 activity, is difficult to ascribe wholly to any one causative factor. The initial sharp rise in iodine-131 in milk on July 20 appears to be circumstantially associated with the trace rains in several parts of the milk collection area on July 15-18 since the second peak of gross beta in air at Salt Lake City occurred during July 15-17. It is also possible that activity from the earlier rains of July 12, 13 and from dry fallout from the July 16, 17 gross beta in air peaks, may have contributed. No single factor can be identified which would account for the peak values for iodine-131 in milk shown on July 25 and 26. As was noted earlier, the iodine-131 activities of the lettuce samples would appear to indicate that no further deposition of iodine-131 took place in the vicinity of Salt Lake City after July 18. However, the 9-day interval between the average dates shown for the iodine-131 values for lettuce, plus the limited area embraced in the lettuce sampling, cannot rule out the possibility that deposition of iodine-131 took place in the milk collection area after July 18.

The decline of iodine-131 activity in milk after about July 26 suggests that the relatively widespread rains during the period July 24-26 and the more scattered rains throughout the rest of the month were relatively free of fresh fission product activity.

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[5] The strontium-90: total beta ratio in lettuce increased from 0.1 percent on July 13 to 0.4 percent on August 6. A personal communication from Dr. E. P. Laug, Division of Pharmacology, Food and Drug Administration, indicates that samples with an age of 6 to 8 months have strontium-90: total beta ratios of 9 to 10 percent

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Comparison of Iodine–131 in Lettuce with Air and Precipitation Data

The first group of lettuce samples, (July 13), were harvested during or after the widespread rains of July 12, 13 in which young fission product activity was observed at Salt Lake City. Hence, it is possible that much of the iodine–131 activity in the first lettuce samples was deposited by the rains of July 12 and 13. Although dry fallout from the July 8 gross beta peak must not be ruled out, the low iodine–131 values for milk up through July 12 give some evidence that the activity in lettuce which might be attributed to dry fallout is not great.

The second group of lettuce samples was harvested on July 18. This group showed the highest iodine–131 activity among the four groups. As with the later sharp rise of iodine–131 in milk (July 20), the July 18 average value for lettuce appears to be associated with the July 15–17 peak in air beta activity and the July 16 trace and light rains in the area immediate to Salt Lake City. The rains of July 13, 14 may have been of equal or more importance. The July 27 iodine–131 concentration in lettuce samples, as discussed earlier, gives no indication that any additional activity was deposited since the July 18 sampling.

Comparison of Air, Precipitation, and Milk Data with Nuclear Detonations

Based on U.S. Weather Bureau meteorological trajectories of nuclear tests given in this report, the RSN July 8 air peak of 595 $\mu\mu c/m^3$ and the initial appearance phase (July 8–12) for iodine–131 in milk would appear to have been due to the July 6 (Sedan) test (see figure 3). However, on the basis of available information, the possibility that the July 7 test (Little Feller II) might have made some contribution cannot be entirely discounted.

There was no distinguishable increase in gross beta activity in air as recorded by the RSN station in Salt Lake City on July 12 and 13. However, based on the July 11 test trajectory (see figure 3) it would appear that most of the gross beta activity in the July 12 and 13 precipitation (see table 3) probably originated with this test. Also, it is difficult to place a precise interpretation on the age of fission products in the precipitation samples for these two days. The peak of gross beta in air on July 15–17 can be most closely associated with the July 14 test, Small Boy, as evidenced by its trajectory. Based on time considerations, at least the first portion of the plateau stage for iodine–131 values in milk (July 13–19) must be largely attributed to the July 11 test (Johnie Boy). The later part of the plateau may have been partly due to precipitation or air contamination affected by Small Boy (July 14).

As pointed out earlier, the sharp rise of iodine–131 in milk on July 20, the beginning of the peak stage, was probably associated with the gross beta in air and the trace precipitation on July 16, 17, and 18. It seems reasonable, therefore, that the July 20 rise in milk is most closely associated with the July 14 Small Boy detonation.

From meteorological trajectories there is little evidence that the July 17 test, Little Feller I, made any marked contribution to the *peak stage* for iodine–131 in milk.

REFERENCES

(*1*) Utah State Department of Health and Salt Lake City Department of Health: *Utah's Experience with Radioactive Milk*, (October 1, 1962).

(*2*) U.S. Weather Bureau: *Daily Weather Map*, (July 7–12, 1962).

(*3*) U.S. Weather Bureau: *Climatological Data*, Utah, (July 1962).

(*4*) R. J. Garner: The Metabolism of Iodine and Strontium in Cows, *The Veterinary Record*, (December 26, 1959).

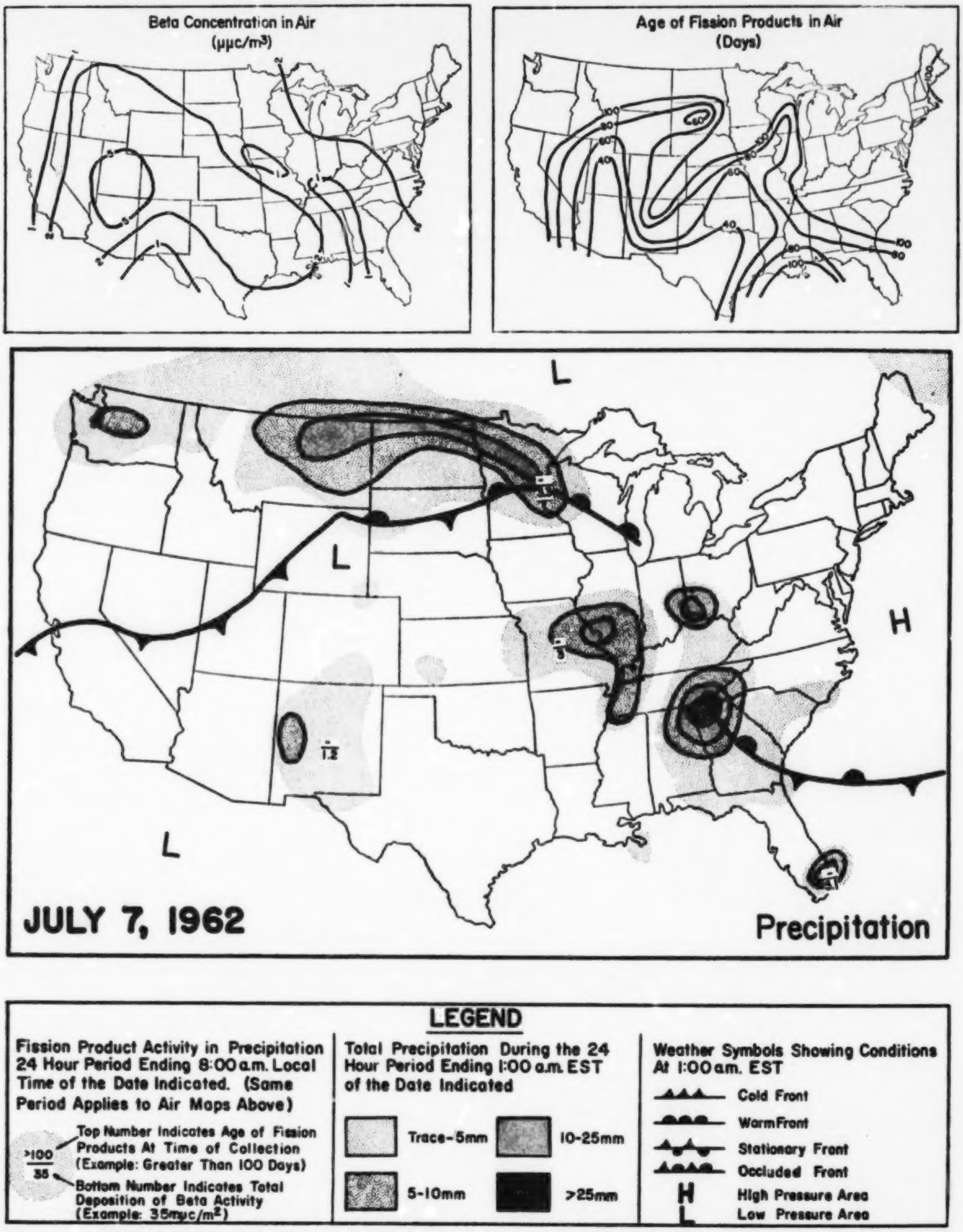
Beta Concentration in Air
(μμc/m³)
Age of Fission Products in Air
(Days)
100
80
60
40
L
L
L
H
1.2
JULY 7, 1962
Precipitation
LEGEND
Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)
>100
35
Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)
Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)
Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated
Trace-5mm
10-25mm
5-10mm
>25mm
Weather Symbols Showing Conditions At 1:00 a.m. EST
Cold Front
Warm Front
Stationary Front
Occluded Front
H High Pressure Area
L Low Pressure Area

Figure 5.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR WITH TOTAL PRECIPITATION

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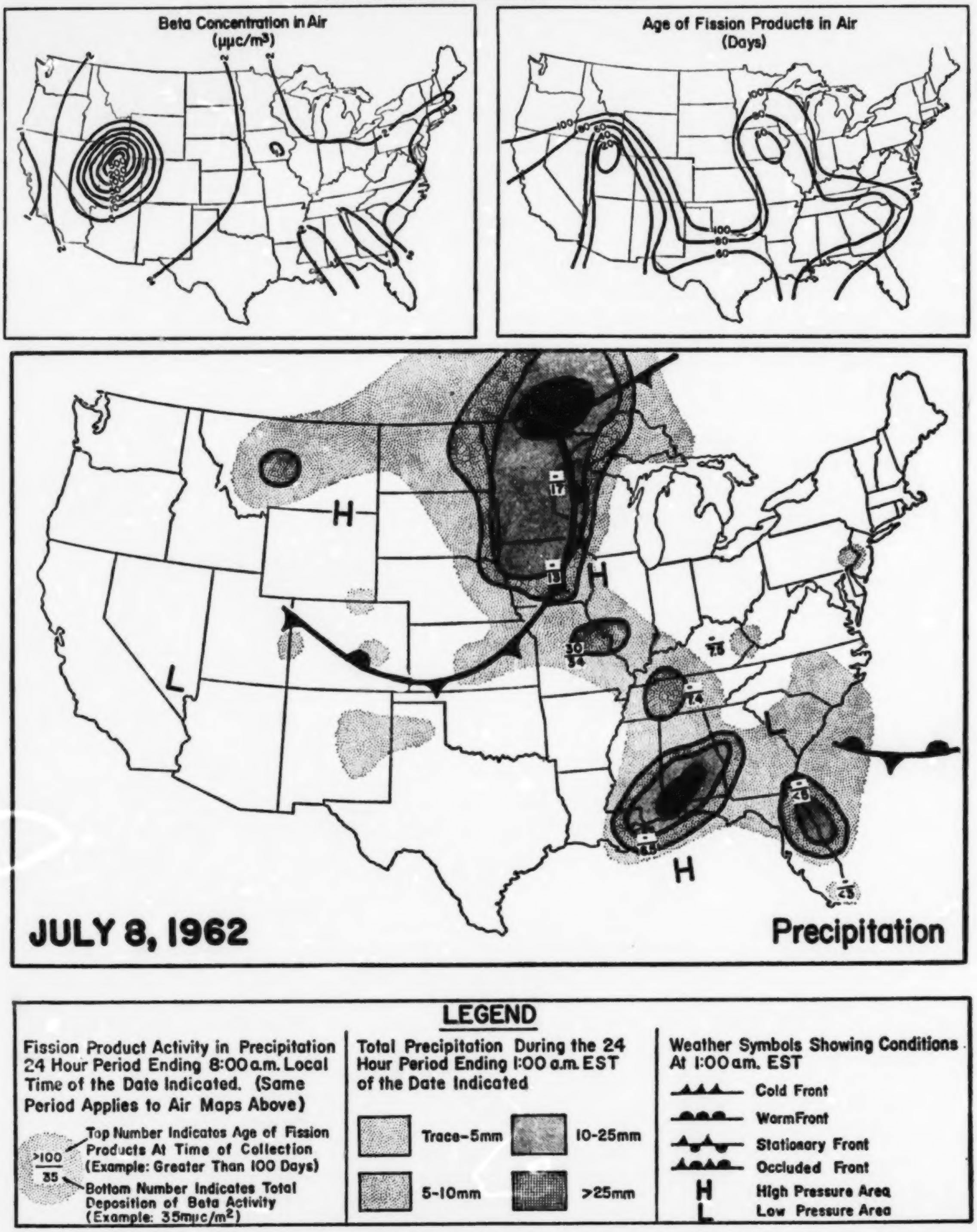
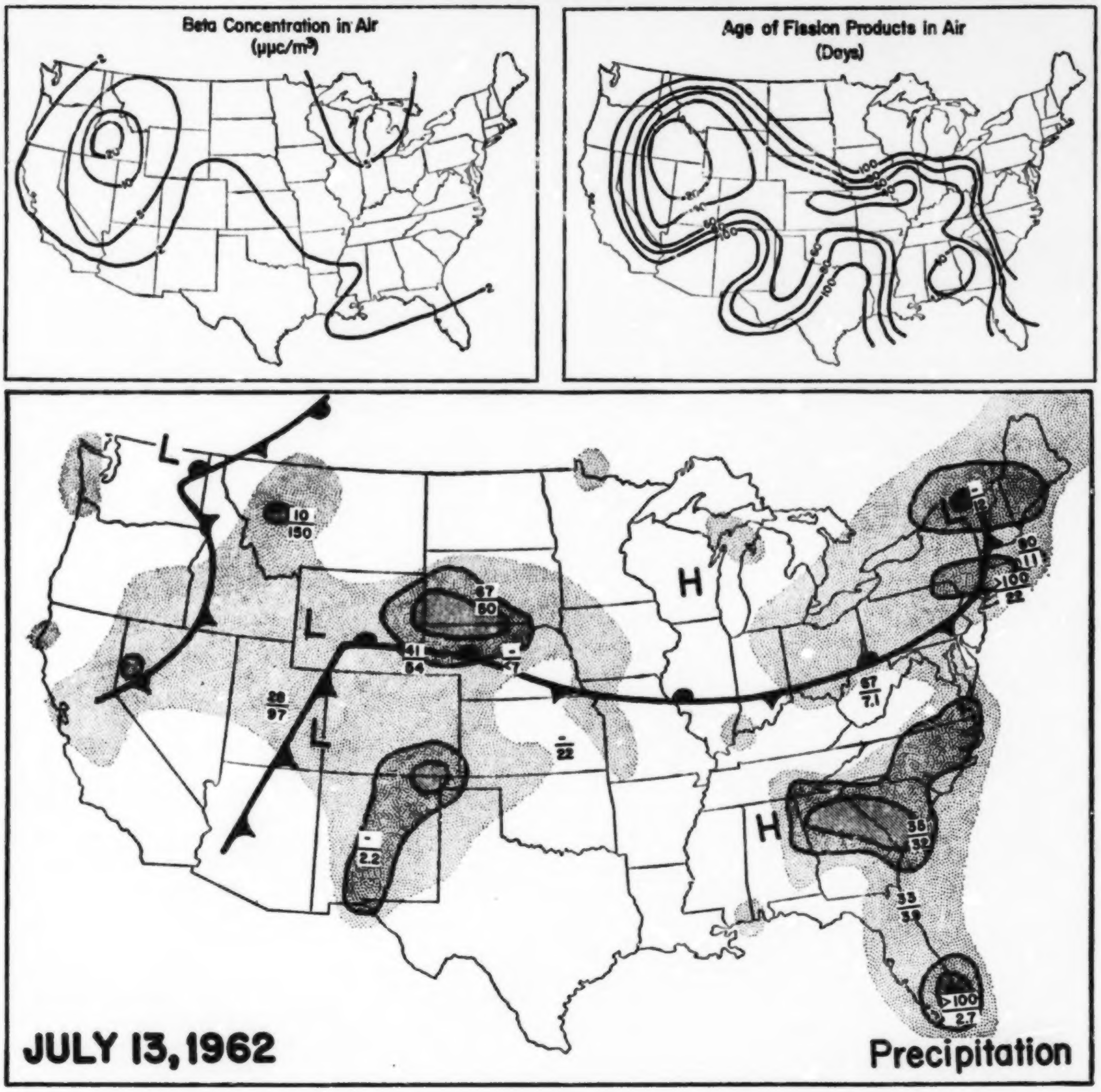

Beta Concentration in Air
(μμc/m³)
Age of Fission Products in Air
(Days)
100
80
60
120
H
L
30
34
75
14
<5
8.5
JULY 8, 1962
Precipitation
LEGEND
Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)
Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)
>100
35
Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)
Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated
Trace-5mm
10-25mm
5-10mm
>25mm
Weather Symbols Showing Conditions At 1:00 a.m. EST
Cold Front
Warm Front
Stationary Front
Occluded Front
High Pressure Area
Low Pressure Area

Figure 5.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR WITH TOTAL PRECIPITATION



Beta Concentration in Air (μμc/m³)

Age of Fission Products in Air (Days)

JULY 13, 1962

Precipitation

LEGEND

Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)

>100 / 35 — Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)
Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)

Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated

░	Trace-5mm	▓	10-25mm
▒	5-10mm	█	>25mm

Weather Symbols Showing Conditions At 1:00 a.m. EST

▲▲▲ Cold Front
●●● Warm Front
▲●▲ Stationary Front
▲●▲ Occluded Front
H High Pressure Area
L Low Pressure Area

Figure 5.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR WITH TOTAL PRECIPITATION

TOTAL PRECIPITATION—Continued

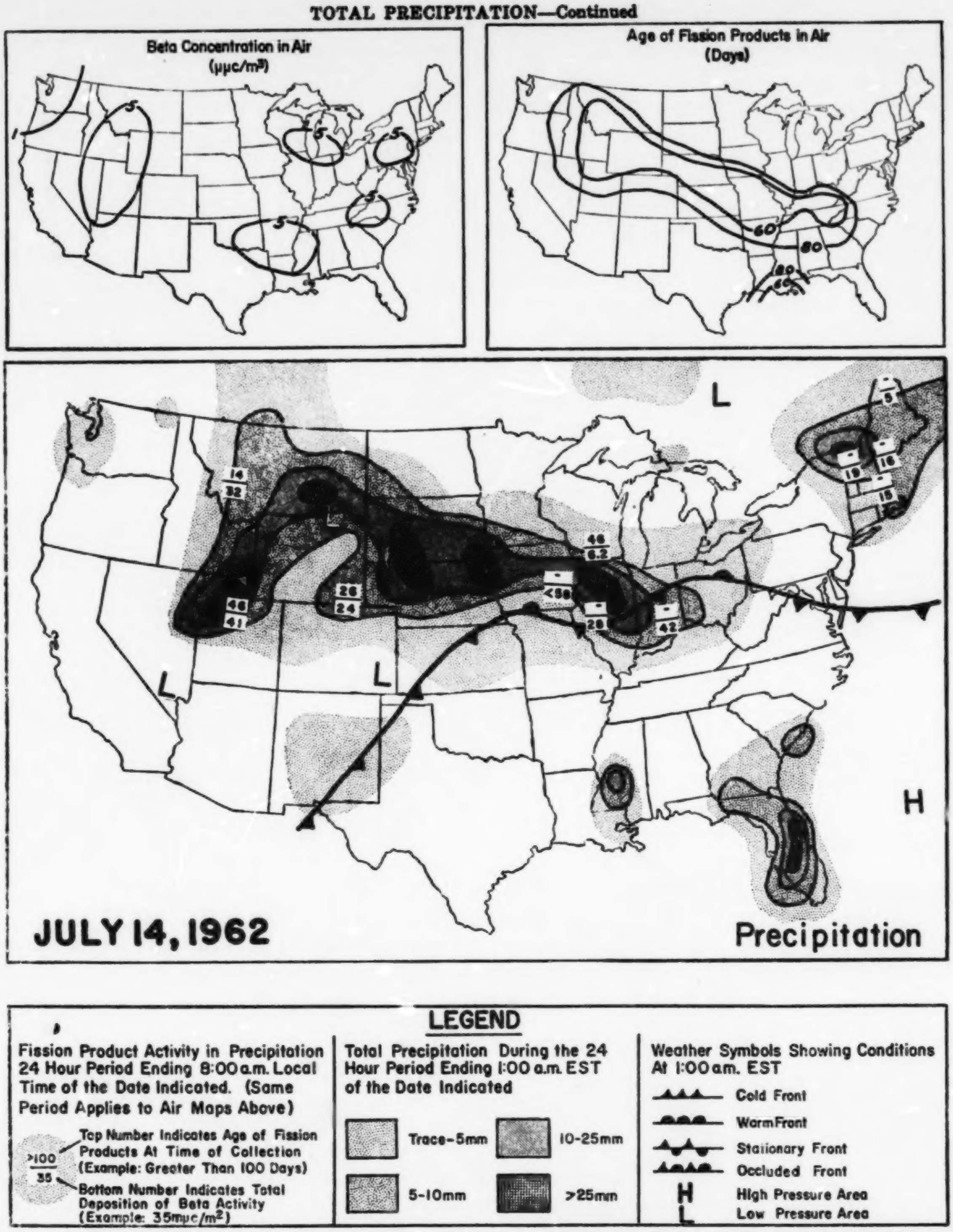

Beta Concentration in Air
(μμc/m³)
5
1
Age of Fission Products in Air
(Days)
60
80
L
H
14
32
46
41
28
24
46
6.2
<98
28
42
5
19
16
15
JULY 14, 1962
Precipitation
LEGEND
Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)
>100
35
Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)
Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)
Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated
Trace-5mm
10-25mm
5-10mm
>25mm
Weather Symbols Showing Conditions At 1:00 a.m. EST
Cold Front
Warm Front
Stationary Front
Occluded Front
H High Pressure Area
L Low Pressure Area

Figure 5.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR WITH TOTAL PRECIPITATION

Strontium–90 in Animal Feeds–1960, 1961, and 1962

Division of Pharmacology, Food and Drug Administration

A part of the continuing surveillance of radioactivity in foods by the Food and Drug Administration is concerned with the levels of radionuclides in animal feeds. The samples are analyzed in a manner similar to that for food items, as indicated in Section II of this issue. Data on the strontium–90 content of animal feeds appear in table 1.

The leafy types of animal feeds, such as alfalfa and lespedeza hays continue to show increased concentrations of strontium–90 over other types of feeds. The geographical and temporal distribution of strontium–90 in alfalfa is shown in table 2. It is clear that strontium–90 concentrations in this animal feed item have increased due to the resumption of nuclear weapons testing.

TABLE 1.—STRONTIUM-90 CONTENT OF ANIMAL FEEDS, 1960, 1961, 1962

Variety	Number samples	pc Sr^{90}/kg	
		Average	Range
Alfalfa hay	33	194	18 -779
Beet pulp	16	62	3.4-127
Corn ensilage	12	30	9.0- 64
Cottonseed meal	11	36	2.9- 95
Lespedeza hay	14	506	45 -960
Peanut hay	15	716	507 -912
Sorghum	4	157	34 -513

TABLE 2.—GEOGRAPHICAL AND TEMPORAL DISTRIBUTION OF STRONTIUM-90 IN ALFALFA

[pc/kg]

Pre-testing averages[a]		Post-testing averages[a]	
West	East	West	East
[b]81 (11)	176 (5)	366 (9)	517 (6)

[a] Samples harvested before Sept. 15, 1961 are designated "pre-test"; after this date, they are called "post-test".

[b] Numbers in parentheses refer to number of samples.

Table 3 shows that hays contain more strontium–90 on a weight basis than fodders, which could include stored feeds. It can be assumed that the fodders have been stored for a period of time. The effect of storage on animal feeds is demonstrated from this table in a limited manner. The hays are probably the most important single vector among the animal feeds for the introduction of strontium–90 into the food chain.

TABLE 3.—COMPARISON OF STRONTIUM-90 CONTENT OF HAYS AND FODDERS

	Number varieties	Number samples	Strontium-90	
			average (pc/kg)	Range (pc/kg)
Hays	3	62	391	18-960
Fodders	4	43	55	2.9-513

Previous coverage in *Radiological Health Data*:

Period	Issue
1959	*December 1960*
1960	*September 1961*
1960 and 1961	*December 1961*
1960	*April 1962*
1960, 1961, and 1962	*August 1962*
1961	*September 1962*

Reported Nuclear Detonations, November 1962

During November 1962, six U.S.S.R. and three U. S. nuclear detonations were announced by the Atomic Energy Commission. Among the U. S. tests was the last of the Operation Dominic series on November 4, after which the Johnston Island Test Area was deactivated.

Test number	Location	Date (1962)	Yield range	Type of test
		REPORTED U.S.S.R. DETONATIONS		
59	Central Asia	November 1	Intermediate	High Altitude
60	Novaya Zemlya	1	Intermediate	Atmospheric
61	Novaya Zemlya	3	Intermediate	Atmospheric
62	Novaya Zemlya	3	Intermediate	Atmospheric
63	Semipalatinsk	4	Intermediate	Atmospheric
64	Semipalatinsk	17	Low	Atmospheric
		REPORTED U. S. DETONATIONS		
93	Johnston Island	1	Submegaton	High Altitude
94	Johnston Island	4	Low	High Altitude
95	Nevada Test Site	27	Low	Underground

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The index is alphabetical with major subject headings and cross-references in boldface type. Each article, subject, or key word is followed by the issue number and page, printed in italics, on which it appeared.

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